No. 126, Original

In The

Supreme Court of the United States

STATE OF KANSAS,

Plaintiff,

v.

STATE OF NEBRASKA

and

STATE OF COLORADO,

Defendants.

FINAL REPORT OF THE SPECIAL MASTER WITH CERTIFICATE OF ADOPTION OF RRCA GROUNDWATER MODEL

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September 17, 2003

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FINAL REPORT OF THE SPECIAL MASTER

By its decree dated May 19, 2003 ("Decree"), this Court approved the Final Settlement Stipulation ("FSS") that all of the parties to this original action, namely, the States of Kansas, Nebraska, and Colorado, had executed and filed with me on December 16, 2002. The FSS laid out the parameters for the RRCA Groundwater Model which would, for use in the accounting formulas for administering the Republican River Compact, determine both stream flow depletions caused by groundwater pumping and streamflow accretions resulting from recharge by imported water. The FSS further prescribed procedures for the timely completion and adoption of the Model by the States. In accordance with Section IV.C of the FSS, the Modeling Committee that was provided for therein completed the RRCA Groundwater Model and submitted it to the States in final form. All three States then approved and adopted the RRCA Groundwater Model prior to July 1, 2003. Accordingly, I present herewith my Certificate of Adoption by the party States of the RRCA Groundwater Model along with documentation of the Model as adopted by the States.

By the Decree the Court also dismissed with prejudice all claims, counterclaims, and cross-claims for which leave to file was or could have been sought in this case arising prior to December 15, 2002, and it made that dismissal effective upon the filing by the Special Master of a final report certifying adoption of the RRCA Groundwater Model by the party States. When the Court hereafter by its customary practice directs that this present report is received and ordered filed, the Court will thereby establish the effective date of the dismissal with prejudice of all claims as ordered by the Decree. By the terms of the

Decree nothing more will remain to be done to bring this action to a conclusion.

Respectfully submitted,

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September 17, 2003

SPECIAL MASTER'S CERTIFICATE OF ADOPTION OF RRCA GROUNDWATER MODEL

I, Vincent L. McKusick, Special Master in this action, hereby certify that the party States of Kansas, Nebraska and Colorado have now completed and adopted the RRCA Groundwater Model in accordance with the terms and conditions of the Final Settlement Stipulation approved by the Court in its Decree dated May 19, 2003. Documentation of the RRCA Groundwater Model as adopted by the States is filed herewith.

Dated: September 17, 2003

VINCENT L. MCKUSICK
Special Master

STATE ADOPTION OF
RRCA GROUNDWATER MODEL,
KANSAS v. NEBRASKA AND COLORADO,
NO. 126, ORIGINAL,
UNITED STATES SUPREME COURT

Pursuant to the terms of the Final Settlement Stipulation herein, the undersigned chief water administration officials and counsels of record hereby adopt the RRCA Groundwater Model, as described and set forth in the attachment hereto.

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REPUBLICAN RIVER COMPACT ADMINISTRATION GROUNDWATER MODEL
June 30, 2003

Executive Summary

In accordance with the December 15, 2002 Final Settlement Stipulation in *Kansas v. Nebraska and Colorado*, No. 126 Original, the Republican River Groundwater Modeling Committee developed a comprehensive groundwater model to represent the groundwater flow system in the Republican River Basin. The primary purpose of the Republican River Compact Administration Groundwater Model (RRCA Model) is to determine the amount, location, and timing of streamflow depletions to the Republican River caused by well pumping and to determine streamflow accretions from recharge of water imported from the Platte River Basin into the Republican River Basin.

Representatives from the State of Colorado, State of Kansas, and State of Nebraska developed the RRCA Model, with participation from the United States Bureau of Reclamation and United States Geological Survey. The data and information used in construction and calibration of the RRCA Model were provided and shared by all three States and the United States in a collegial manner. In a similar vein, the RRCA Model was constructed and calibrated in a collaborative exercise by technical experts from all three States.

The RRCA Model is fully operational and calibrated to represent the physical and hydrogeological characteristics of the Republican River Basin to a reasonable degree. The RRCA Model matches the trend and magnitude of groundwater level changes and stream baseflow targets distributed throughout the Republican River Basin,

without significant bias in any region or hydrologic characteristic. The RRCA Model is calibrated to a sufficient degree that depletions from groundwater pumping and accretions from imported water from the Platte River System to the Republican River may be quantified and assigned to prescribed streamflow reaches in accord with the RRCA Accounting Procedures.

I. Introduction

The Republican River rises in the high plains of northeastern Colorado and western Kansas and Nebraska. The river flows in a generally eastern direction and encompasses approximately 24,900 square miles within its watershed that is illustrated below. The States of Colorado, Kansas, and Nebraska, with the consent of the United States of America, entered into the Republican River Compact in 1943 in order to equitably divide the waters of the Republican River Basin. Groundwater accretions and depletions are subject to administration within the Compact for the portion of the basin that contributes flow above the streamflow gaging station on the Republican River near Hardy, Nebraska which is in the eastern part of the Republican River Basin near the Kansas-Nebraska state line.

The Final Settlement Stipulation (FSS) in *Kansas v. Nebraska and Colorado*, No. 126 Original, which resolved that interstate dispute, provided for development of a comprehensive groundwater model to represent the groundwater flow system in the Republican River Basin. This document describes the content, construction, and calibration of the Republican River Compact Administration Groundwater Model (RRCA Model). Representatives from

the State of Colorado, State of Kansas, and State of Nebraska developed the RRCA Model, with participation from the United States Bureau of Reclamation and United States Geological Survey (USGS).

A. Purpose and Scope

The primary purpose of the RRCA Model is to determine the amount, location, and timing of streamflow depletions to the Republican River caused by well pumping and to determine streamflow accretions from recharge of water imported from the Platte River Basin into the Republican River Basin above the streamflow gaging station near Hardy, Nebraska. The RRCA Model construction and calibration represent the physical and hydrogeological characteristics of the Republican River Basin to a reasonable degree for the period 1918 to 2000. The RRCA Model simulates historical and current physical conditions; it is not an optimization or operational model and does not assess the impact of land use and conservation practices, reservoir operations, or other water supply or water administration practices.

The RRCA Model will be used to determine groundwater depletions and imported water supply accretions in formulas prescribed in the RRCA Accounting Procedures. Future input data to the RRCA Model will be developed in accordance with the requirements of the Accounting Procedures.

B. Document Context

This document is intended to provide a detailed description of all major facets in the RRCA Model structure, data and information, calibration, and results that were reached in its construction by the State of Colorado, State of Kansas, and State of Nebraska in consultation with the United States. Updated with annual streamflow, climatological, irrigated acreage, groundwater pumping, and other information, the RRCA Model will be used to quantify said streamflow depletions caused by well pumping and imported water supply accretions for application within the formulas prescribed in the RRCA Accounting Procedures. The data and information used in construction and calibration of the RRCA Model were provided and shared by all three States and the United States in a collegial manner. In a similar vein, the RRCA Model was constructed and calibrated in a collaborative exercise by technical experts from all three States. This document reflects the RRCA Model architecture, the data sets used, and calibration agreed upon by the States as required by the FSS.

The RRCA Model, consisting of the computer code, input files, and pre-processing and post-processing programs, is provided in Appendix A on a DVD ROM. Members of the RRCA Engineering Committee are working on a RRCA Groundwater Model Users Manual that will provide details related to the use of the model in conjunction with the RRCA Accounting Procedures. The Users Manual will discuss data content and formatting, the use of pre-processing programs, details on completing the various runs of the model, and application of the RRCA Model's outputs in the annual RRCA accounting.

C. Model Findings and Summary

The RRCA Model is fully operational and calibrated to represent the physical and hydrogeological characteristics of the Republican River Basin to a reasonable degree. The RRCA Model reasonably matches the trend and magnitude of groundwater levels and stream baseflow targets distributed throughout the Republican River Basin, without significant bias in any region or hydrologic characteristic. The RRCA Model is calibrated to a sufficient degree that depletions from groundwater pumping and accretions from imported water from the Platte River System to the Republican River may be quantified and assigned to prescribed streamflow reaches in accord with the RRCA Accounting Procedures.

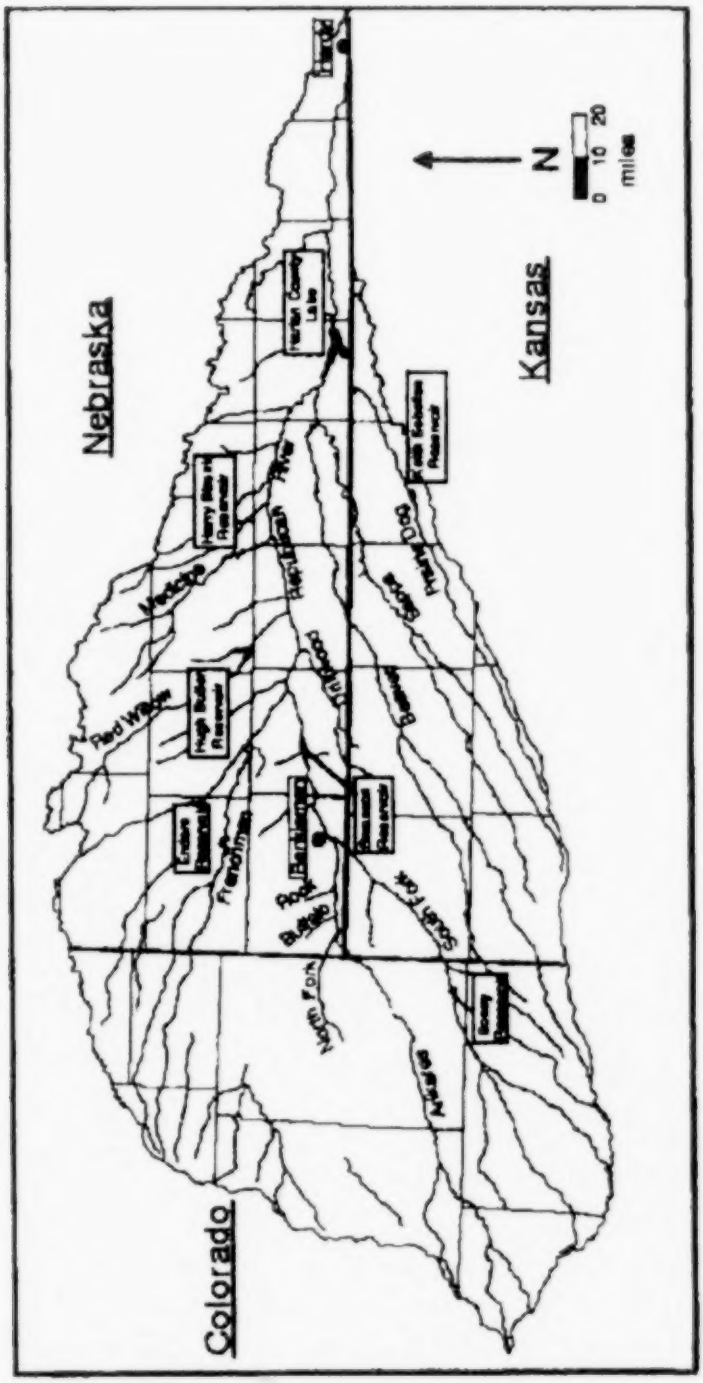
II. Conceptual Model of Groundwater Flow System

A. Background and Physical Setting

The tributaries at the headwaters of the Republican River rise on the high plains of northeastern Colorado and western Kansas and Nebraska. The mainstem of the Republican River is formed by the junction of the North Fork of the Republican River and the Arikaree River near Haigler, Nebraska. The river flows in a generally eastern direction for approximately 445 miles before it joins the Smoky Hill River to form the Kansas River at Junction City, Kansas. The Republican River Basin encompasses approximately 24,900 square miles within its watershed that is illustrated below.

In order to include all groundwater resources that affect stream flows within the Republican River Basin, the RRCA Model domain was extended beyond the Republican River watershed. The model domain boundaries extend

from the Platte River in the north to the Ogallala Aquifer outcrops on the southern, eastern, and western boundaries. The model domain coincides with that described in USGS Open File Report 02-175 except in the eastern portion of the Basin where it was extended eastward to the eastern edge of Kearney County, Nebraska and into Adams County, Nebraska to reflect increased water table elevations caused by imported water supplies from the Platte River. The model domain encompasses approximately 30,000 square miles. A map of the model domain, including model cell designations and boundary conditions, is provided in Appendix B.


Nebraska
Kansas
Colorado
N
0 10 20
miles
Harlan County Lake
Harry Strunk Reservoir
Medicine
Red Willow
Hugh Butler Reservoir
Enders Reservoir
Frenchman
Republican River
Swanson Reservoir
Buffalo
Bonny Reservoir
North Fork
Arikaree
South Fork
Beaver
Prairie Dog
Keith Sebelius Reservoir

B. Hydrogeology Framework

The predominant source of groundwater supply within the Republican River Basin is the shallow alluvium and deeper bedrock formations that collectively form the High Plains Aquifer. The High Plains Aquifer underlies portions of eight western States, including Colorado, Kansas, and Nebraska, and the topography is characterized by flat to gently rolling terrain that is bisected by mostly eastward-flowing rivers and streams, such as the Republican River. The predominant geologic unit of the High Plains Aquifer is the Miocene-aged Ogallala Formation of the Tertiary period. The Ogallala Formation principally consists of unconsolidated to semi-consolidated sands, gravels, clays, and silts. The High Plains Aquifer is also composed of the shallower river alluvium and eolian deposits of the later Quaternary period. Water-table or unconfined conditions are predominant throughout the Aquifer. However, in some areas the hydraulic interconnection between the stream systems and geologic units may have been broken and in other localized areas cemented "mortar" (caliche) beds are common and create artesian or confined aquifer conditions.

The depositional history of the High Plains Aquifer is complex because it contains both fluvial (stream-deposited) and eolian (wind-deposited) sediments. Braided streams systems that flowed eastward across the alluvial fans adjacent to the Rocky Mountains served as the primary source of deposition of coarse-grained and fine-grained sediments to the Ogallala Formation during the Tertiary time period. However, in the Quaternary period, as the climate in the area turned drier and colder due to mountain uplift, the major form of sediment deposition changed to eolian. The winds transported the fine

materials caused by braided stream erosion in dust storms that carried very fine to medium sands to the east before settling into dune deposits, the largest and most prominent being located in west-central Nebraska. The Quaternary age alluvial, valley-fill, dune sand, and loess deposits are also considered to be part of the High Plains Aquifer where they are hydraulically connected to the underlying Ogallala Formation.

The saturated thickness of the High Plains Aquifer ranges from zero in the western edge of the aquifer in Colorado where the aquifer outcrops, to approximately 1,000 feet in west-central Nebraska. Groundwater flow in the High Plains Aquifer is generally from west to east in response to the predominant slope of the water table.

C. Water Budget

The water budget for the Republican River Basin changed dramatically over the simulation period of 1918-2000. As anticipated, during the pre-development period the natural precipitation recharge, evapotranspiration and stream gains were the only significant stresses on the system. Beginning in the 1940's, accretions from surface water canals in the Platte River Basin began to migrate into the Republican River Basin groundwater system and introduce a significant new recharge into the system. Well pumping increased from approximately 1950 to 1980, then essentially leveled off but continued its impact as a major stress on the system. Coincident with well pumping increases, return flows from groundwater irrigation became a significant source of recharge. For illustrative and comparative purposes, the selected water budget components are tabulated below and a graphical representation is provided in Appendix C.

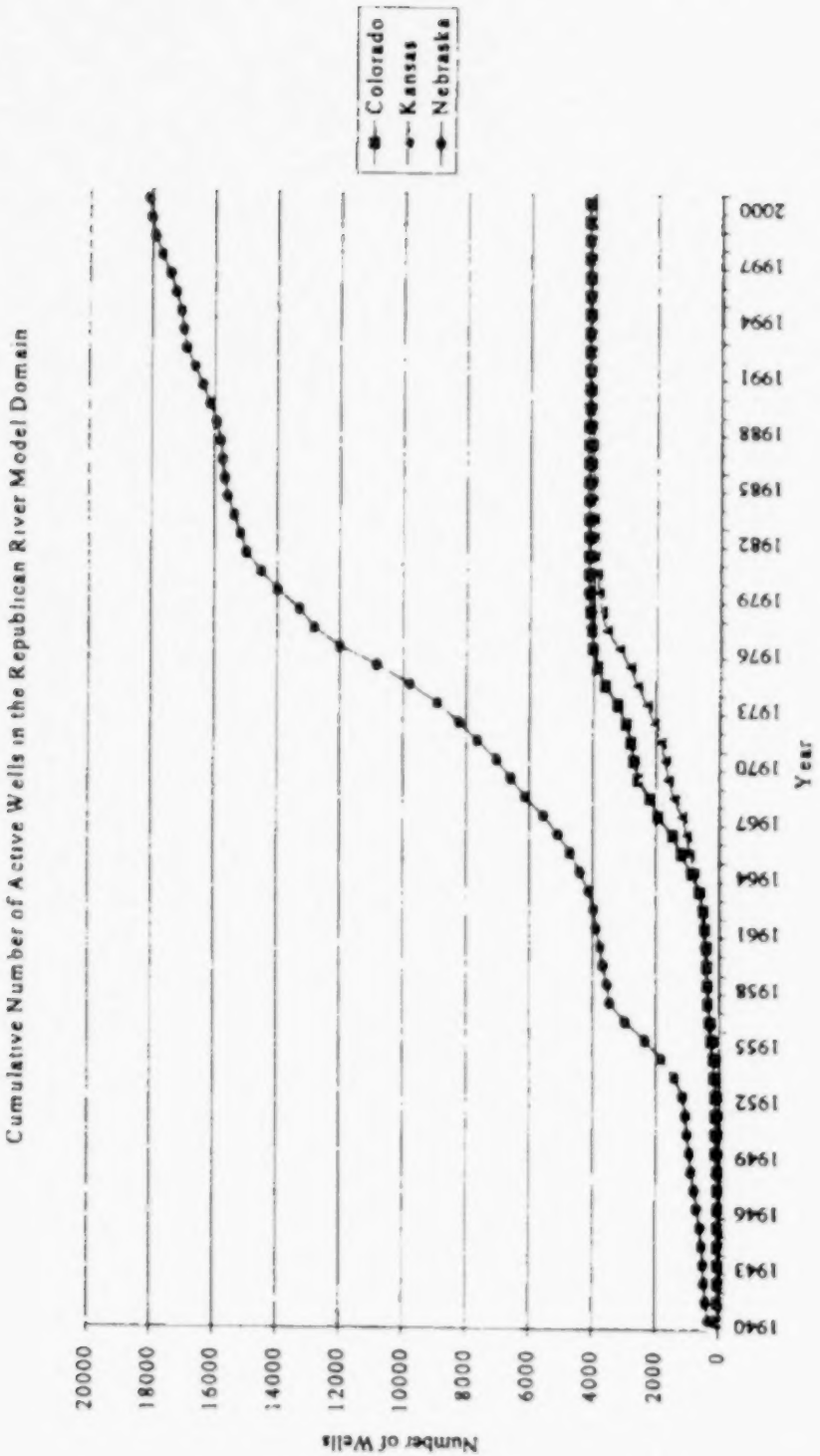
RRCA Model Global Water Budget Annual Average Amount in acre-feet						
Years	Inflows					
	Precipitation Recharge	Groundwater Recharge	Surface Water Recharge	Canal Leakage	Stream Losses	Decrease in Storage
1921-1930	1,440,697	0	0	0	222,780	424,581
1931-1940	601,512	1,264	421	15,996	229,750	632,529
1941-1950	1,916,460	15,262	47,777	632,988	208,071	467,162
1951-1960	1,283,039	69,083	99,152	652,719	207,269	812,763
1961-1970	1,479,667	237,718	102,332	598,784	230,134	1,217,401
1971-1980	1,452,260	595,112	111,638	665,139	236,637	2,511,248
1981-1990	1,740,645	572,102	101,767	623,134	233,679	2,309,917
1991-2000	1,998,741	498,803	86,742	607,402	234,982	2,221,763

RRCA Model Global Water Budget Annual Average Amount in acre-feet						
Years	Outflows					
	Phreatophyte ET	Springs	Well Pumping	Constant Head Boundaries	Stream Gains	Increase in Storage
1921-1930	477,250	65,435	6,227	167,033	448,280	923,836
1931-1940	460,743	65,368	10,059	165,869	439,771	339,611
1941-1950	466,106	76,599	52,441	434,574	511,874	1,746,297
1951-1960	502,402	86,981	227,993	581,770	489,936	1,234,618
1961-1970	542,580	86,624	898,512	553,367	509,096	1,276,170
1971-1980	493,572	85,542	2,553,584	557,971	466,483	1,414,830
1981-1990	487,373	83,919	2,595,959	575,350	426,078	1,412,304
1991-2000	470,615	87,937	2,537,878	554,059	411,616	1,586,317

D. Groundwater Pumping

1. Irrigation Pumping

Groundwater pumping for irrigation of croplands in the Republican River Basin was limited prior to World War II but progressed rapidly in the 1960's and 1970's. The cumulative number of irrigation wells within the Republican River model domain over time is illustrated in the graph below. The States agreed to accept the method each one developed to estimate gross irrigation pumping within their respective boundaries for the period 1940-2000. The methods used by each State for estimating historical groundwater pumping and tabulations of the annual pumping estimates are provided in Appendix D.


Cumulative Number of Active Wells in the Republican River Model Domain
Colorado
Kansas
Nebraska
Number of Wells
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
Year
1940
1943
1946
1949
1952
1955
1958
1961
1964
1967
1970
1973
1976
1979
1982
1985
1988
1991
1994
1997
2000

2. Pumping for Municipal and Industrial Uses

The pumping for municipal and industrial purposes for Colorado and Nebraska was obtained from the USGS and subsequently verified and refined by each state. Kansas developed its estimates from its wateruse database. Municipal and industrial pumping estimates include those quantities equal to or greater than 50 acre-feet/year.

E. Recharge

Recharge into the groundwater aquifers is from two primary sources of water: recharge from precipitation and recharge from human-induced activities such as irrigation of cropland and seepage from ditches/canals. Recharge from irrigation is further segmented into two principal components based upon the source of water – surface water or groundwater. The following narrative describes how these components were estimated for the period 1940-2000.

1. Recharge from Precipitation

Precipitation recharge is a significant variable in the overall water budget because it affects the entire model domain of over 19 million acres. Average precipitation between 1918 and 2000 varies from approximately 16 inches per year in the western part of the study area to approximately 27 inches per year in the eastern part of the Basin. Recharge from precipitation generally increases from west to east across the domain. Recharge from precipitation is also influenced by soil type. More recharge is generated on coarse textured soils than fine textured soils for the same amount of precipitation. Therefore, STATSGO soil maps were initially used to locate sandy

soils in the domain. These areas are commonly referred to as the *sand hills* of Colorado and western Nebraska. In a similar manner, medium and fine textured soils were identified. For simplicity, the three soil classifications used in the RRCA Model are described as coarse, medium, and fine. The final distribution of soils across the model domain is illustrated in Appendix E.

Recognizing the amount of precipitation that recharges the groundwater aquifer increases in proportion with the amount of precipitation, a set of two curves was developed for each soil classification. One curve is for irrigated lands and the other for non-irrigated lands. The Y-axis for each curve represents the number of inches of recharge from precipitation and the X-axis depicts the total amount of precipitation each year. In addition to the curves developed for the three predominant soil classifications, a two-curve precipitation recharge set was similarly developed for tributary alluviums and another for the main stem of the Republican River alluvium to represent their unique recharge and soil characteristics. The curves were developed from historical climate information and analysis of output from theoretical soil-water balance computer models and refined as part of the calibration process. The extent of the increase in precipitation recharge for irrigation conditions relative to non-irrigated conditions was the subject of extensive discussion and the resulting recharge curves represent a compromise agreement that shall not be considered a precedent toward application of precipitation recharge to surface water accounting. The Precipitation Recharge Curves are provided in Appendix F and the amount of recharge from precipitation is tabulated in Appendix G.

2. Recharge from Groundwater Irrigation

Recharge from groundwater irrigation for all three States is calculated as the product of estimated pumping multiplied by an appropriate efficiency factor. The following methods are applied to calculate recharge from groundwater irrigation in each State for 1940-2000 and the amount of groundwater recharge is tabulated in Appendix H.

Colorado – Recharge from groundwater pumping in Colorado is calculated for each year and for each county. Groundwater recharge from sprinkler irrigation is calculated by multiplying the gross pumping for sprinkler irrigation by the percentage that returns as deep percolation. In a similar manner, the amount of groundwater recharge from flood irrigation is calculated by multiplying the gross pumping for flood irrigation by the percentage that returns to the aquifer as deep percolation. The total amount of recharge from groundwater per county and year is the sum of the returns to deep percolation from sprinkler and flood irrigation.

Kansas – Recharge from groundwater irrigation was calculated by subtracting the net pumping from the gross pumping, and deducting spray loss for sprinkler irrigation or surface water runoff on lands that are flood irrigated. The average percentage of pumping lost to spray loss was 6% until 1986 and declined to 3% in more recent years. The net surface water runoff from flood irrigation is 5%. Once the county monthly pumping and return flow values were calculated, they were distributed to the sections within the county using the annual well count and irrigated acreage. A section's percentage of the county's total irrigated acreage was calculated and multiplied by the

county pumping and return flows to obtain values for the section.

Nebraska – Based on professional judgment, Nebraska assumed recharge rates that are generally inverse to assumed farm efficiency. Nebraska applies a groundwater irrigation efficiency of 70% from 1940 to 1960 and a linear increase from 70% in 1960 to 80% in 2000. These percentages were checked for reasonableness using information available on the number of wells and number of center-pivot irrigation systems for each year.

3. Recharge from Canals and Laterals

A number of canal systems supply surface water for irrigation within the domain that influences flow in the Republican River and its tributaries. Seepage from these canals and their corresponding laterals is specified in the model as a recharge term. The calculation of canal and lateral seepage recharge specified in the model is dependent on the type of canal system as summarized in the table below. Recharge estimates from canals and laterals are tabulated in Appendix I.

Canal System Type	Method for Calculating Canal and Lateral Seepage Recharge
Small Non-Federal Ditches and Canals	Recharge from canal seepage and from surface water irrigation is combined into one term. The total amount of recharge for both the canal seepage and surface water irrigation is calculated to be 40 percent of tabulated diversions.

Federal Canals (Maintained by the US Bureau of Reclamation)	Recharge from canal seepage calculation based on methodology specified in Section IV.A.2.c in the RRCA Accounting Procedures.
Platte River Canals	Where available canal seepage was determined from measured farm headgate deliveries and diversions at the headgate with estimated evaporation from the canal surface subtracted out. Where these data were not available canal loss rates were estimated using the rates from like canal systems with available data.

4. Recharge from Surface Water Irrigation

Surface water irrigation recharge was specified based on a percentage of the water delivered to farm headgates by canal systems and small pumping plants that extracted water directly from surface water bodies. The methods used to calculate surface water irrigation recharge are provided in the table below. Recharge estimates from surface water are tabulated in Appendix J.

Canal System Type	Method for Calculating Surface Water Irrigation Recharge
Small Non-Federal Ditches and Canals	Recharge from canal seepage and from surface water irrigation is combined into one term. The total amount of recharge for both the canal seepage and surface water irrigation is calculated to be 40 percent of tabulated diversions.

Federal Canals (Maintained by the US Bureau of Reclamation)	Recharge from surface water irrigation calculation based on methodology specified in Section IV.A.2.c in the RRCA Accounting Procedures.
Platte River Canals	Recharge from surface water irrigation was specified to be 40 percent of farm headgate deliveries for 1940 to 1960 linearly decreasing to 30 percent in 2000.
Small Surface Water Pumping Plants	Recharge was specified to be 25 percent of the water diverted.

F. Irrigated Acreage

The States agreed to methods for estimating irrigated acreage for the period 1940-2000, which are documented in Appendix K. The summary of the total estimated irrigated acreage at the beginning of each decade is provided below and the estimates by county and year for each State are tabulated in Appendix K.

Total Estimated Irrigated Acreage in Republican River Basin

Year	Colorado	Kansas	Nebraska
1940	5,409	2,952	22,427
1950	15,900	6,080	188,031
1960	62,736	50,882	451,385
1970	428,009	196,831	638,969
1980	664,161	357,710	1,428,685
1990	667,351	402,132	1,498,400
2000	667,891	434,767	1,654,452

G. Crop Irrigation Requirements

Colorado – The potential irrigation requirement for each crop for each county and year was estimated using the Hargreaves equation calibrated to the Penman-Monteith equation and is tabulated in Appendix L. The crop mix was obtained from County Assessor data. Effective rainfall was estimated using the procedure outlined in Irrigation Water Requirements, Technical Release No. 21, United States Department of Agriculture, April 1967 (Revised September 1970). The gain in soil moisture from winter and spring precipitation was an average of 2.0 inches (source: Republican River Basin Water Management Study, Steven J. Vandas, United States Bureau of Reclamation, March 1983). The net crop irrigation requirement was calculated as the potential consumptive use minus effective precipitation minus the gain in soil moisture from winter and spring precipitation.

Kansas – Using the Hargreaves equation calibrated to the Penman-Monteith calculations and effective rainfall from TR-21, the composite crop-weighted unit CIR was obtained for each year. At climate stations for which the requisite data to calculate the CIR for 1940-1949 were not available, data from a nearby station were substituted. The unit CIR for 1940-2000 was multiplied by the irrigated acreage described above to obtain volume of irrigation demand for each county. To account for winter soil moisture, a preliminary soil moisture factor was applied to each county in April and, if necessary, May, and was used to offset the CIR at the beginning of the irrigation season. The remaining CIR was then used as an initial estimate of net pumping.

Nebraska – Crop irrigation requirements are not estimated in the Nebraska procedure.

H. Streams and Reservoirs

The RRCA Model considers only the impact of groundwater pumping and surface water imports to the baseflow for the major streams in the Republican River Basin. It is not a surface water model and total streamflows are not incorporated in its design or calculations. The stream network was adopted from the USGS Republican River Study and a schematic diagram is shown in Appendix M. The seven major federal reservoirs were simulated in the RRCA Model using historical elevations or reservoir stages.

I. Phreatophytes

The potential evapotranspiration rate for the various classifications of phreatophyte vegetation (forest, woody, and marsh) was collapsed into a single ET rate that was calculated by the Hargreaves method using appropriate equivalent crop coefficients. Results were obtained for the Akron, McCook, and Red Cloud climate stations on a monthly time step. For selected Sub-basins, the change or encroachment of phreatophytes over time was adjusted in accordance with the curvilinear time-relationship developed from aerial photographic data provided by Michaela Johnson in a published Master's Thesis (Johnson, 2001) with refinements based on observed streamflows during calibration. The methods used by each State to calculate and assign phreatophyte distribution are provided in Appendix N. The phreatophyte potential evapotranspiration rates used in the RRCA Model are tabulated in

Appendix N in addition to the Sub-basin phreatophyte potential evapotranspiration factors that reflect the expansion of phreatophytes over time.

J. Discussion of Flow Pattern

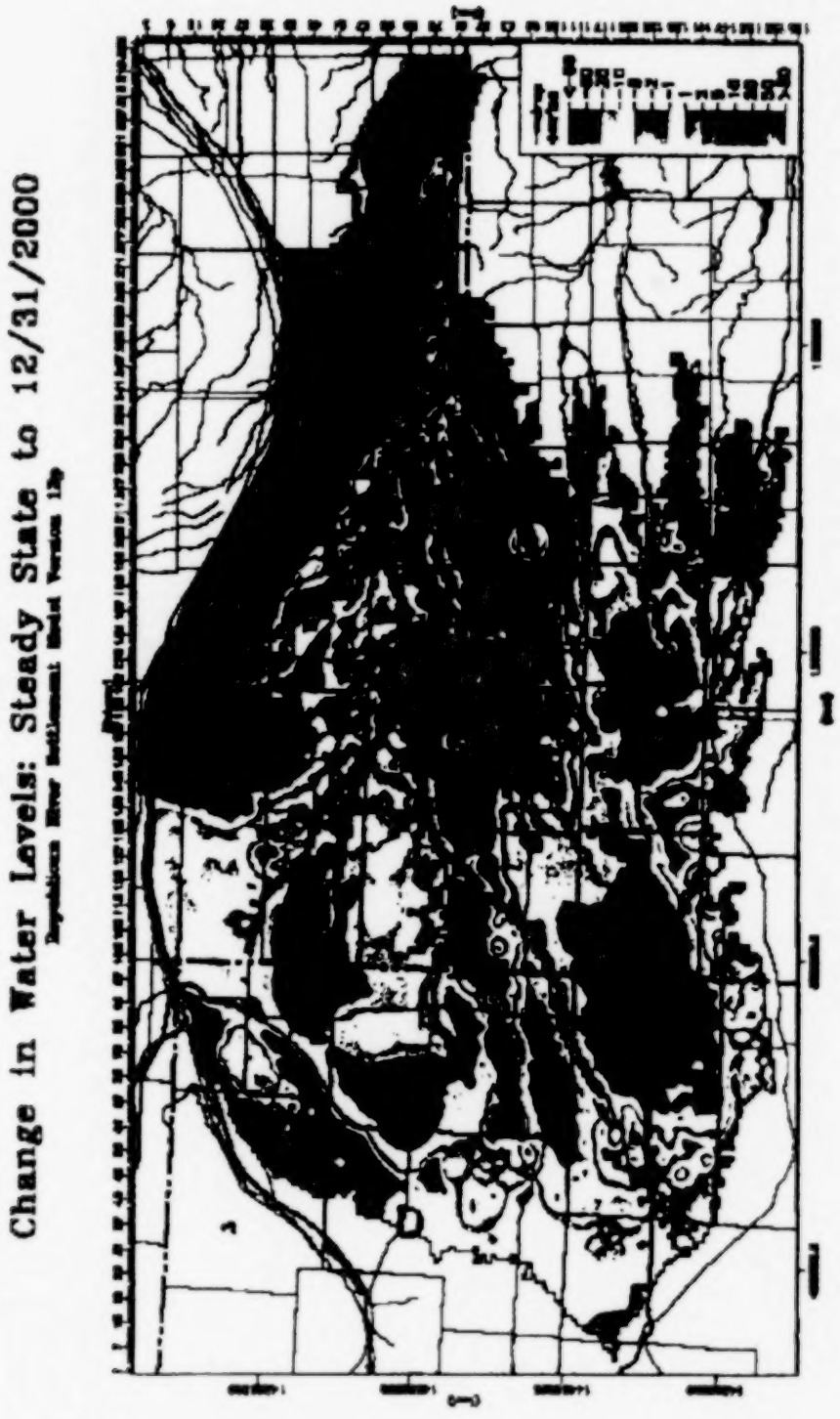
The general direction of water flow in the Republican River Basin is west to east with tributaries intersecting from both the southern and northern boundaries to the mainstem in the center of this gourd-shaped watershed. In the extreme north-central portion of the basin in Nebraska, there is a small amount of groundwater flow from the Republican River Basin north toward the Platte River Basin. Further east, groundwater migrates south from the Platte River Basin into the Republican River Basin in the northeastern portion area of the watershed referred to as the "mound area" that is approximately centered on the 99th Meridian. Headwaters of the Republican River are born on the high plains of eastern Colorado and combine with tributaries from southwestern Nebraska and northwestern Kansas to form the mainstem of the Republican River at the confluence of the North Fork of the Republican River and Arikaree River near Haigler, Nebraska. The Republican River flows eastward and generally parallel to the Nebraska-Kansas stateline before turning in a southeastern direction to cross the border near Hardy, Nebraska. The Republican River meets the Smoky Hill River at Junction City, Kansas to form the Kansas River, a major tributary to the Missouri River.

Streamflows are captured and retained in seven federal reservoirs that are within the Republican River Basin upstream of the Nebraska-Kansas stateline near Hardy, Nebraska. The reservoirs and associated tributary

streams are as follows, progressing from the headwaters downstream:

Bonny Reservoir	South Fork of the Republican River, Colorado
Swanson Lake	Mainstem of the Republican River, Nebraska
Enders Reservoir	Frenchman Creek, Nebraska
Hugh Butler Lake	Red Willow Creek, Nebraska
Harry Strunk Lake	Medicine Creek, Nebraska
Keith Sebelius Lake	Prairie Dog Creek, Kansas
Harlan County Lake	Mainstem of the Republican River, Nebraska

The RRCA Model predicted change in water levels vary dramatically across the Republican River Basin from the pre-development period through 2000. The maximum rise in water level is approximately 179 feet in the mound area in Nebraska and the greatest decline is approximately 86 feet near Burlington, Colorado. For illustrative purposes, the predicted change in water levels in the RRCA Model domain is shown below.


Change in Water Levels: Steady State to 12/31/2000

III. Mathematical Representation of Groundwater Flow Model

A. Model Program

The RRCA Model applies a modified version of the United States Geological Survey modular groundwater model MODFLOW 2000 (Harbaugh and others, 2000) version 1.10 to numerically calculate stream depletions from groundwater pumping and accretions from imported water supplies. MODFLOW is a simulation program that uses a finite-difference method to solve the groundwater flow equation.

In addition to its robust numerical solver capabilities, MODFLOW also offers two significant attributes. First, it is relatively easily understood, which promotes confidence in its application by those intending to use the computer model to simulate physical and hydrological conditions. Second, it is easily enhanced to accommodate the continuing need for additional capabilities to address a variety of physical and hydrogeological conditions.

The MODFLOW program promotes simulation accuracy and computational flexibility by segmenting various hydrologic attributes such as recharge, leakage from the aquifer to the rivers, or evapotranspiration from groundwater as separate or distinct packages. For application within the RRCA Model, the following enhancement modules or packages were used:

- Basic (BAS6)
- Layer Property Flow (LPF1)
- Recharge (RCH6)
- Well (WEL6)

- Stream (STR6)
- Evapotranspiration (EVT6)
- Drains (DRN6)
- Preconditioned Conjugate Gradient (PCG2)
- Hydrograph (HYMOD1)

B. Model Architecture

The following items are the major components in the RRCA Model architecture:

- The model is a single layer bounded on the bottom by the impermeable Pierre Shale.
- The initial Stream Network was taken from USGS Open File Report 02-175.
- The interim aquifer base was taken from USGS Open File Report 02-175, and was adjusted to reflect elevation variances near streams and data available from Nebraska.
- Land surface elevations were obtained from the National Elevation Dataset (NED) one arc second Digital Elevation Model (DEM). The land surface elevations along stream channels were modified in order to provide strictly decreasing elevations along stream channels.
- The groundwater flow system was simulated as if there were a constant transmissivity in order to preserve numerical stability.

1. Simulation Period

The RRCA Model represents the long-term steady-state conditions prior to 1918 and transient conditions from 1918 to 2000. Transient conditions are discretized into monthly stress periods. The RRCA Model will be updated annually by the RRCA to reflect data from 2001 to the current accounting year.

2. Discretization

The RRCA Model is spatially discretized into one-square mile grid cells and temporally discretized into one-month stress periods, with two time-steps per stress period.

3. Boundary Conditions

Constant head boundary conditions for the model were assigned along the Platte River, the eastern boundary of Kearney, Clay, Nuckolls, and Adams Counties, Nebraska; and in Cheyenne County, Colorado where the Ogallala Aquifer continues south of the Republican River Basin. All other boundaries are no-flow boundaries or drains. See Appendix B, RRCA Model Domain for boundary and drain locations.

4. Initial Conditions

The steady state recharge, or initial condition, was established on the premise of no groundwater irrigation prior to 1940. The historical recharge for the period of 1918-1940, assuming no irrigation, was used in conjunction with the developed recharge curve(s) to obtain the recharge for each year. The recharge obtained for each

year in the 1918-1940 period was averaged and assigned as the initial recharge condition in 1918, also known as the steady state condition. A global multiplier called the steady state multiplier was used to adjust the steady state recharge. During model calibration, the value of the steady state multiplier was established at 0.75, in part to replicate the long-term upward trend in the hydrographs observed in the western part of the domain.

5. Aquifer Parameters

The RRCA Model considers two aquifer parameters:

- The specific yield values were obtained from previous USGS investigations and reports and are portrayed in the Distribution of Specific Yields in Appendix O.
- Hydraulic conductivities were quantified through the calibration process and are portrayed in the Distribution of Hydraulic Conductivities in Appendix P.

6. Stresses

Calculation of the model stresses is fairly complex due to the variance in the three States' data and methods used to calculate well pumping for groundwater irrigation, surface water irrigation and the associated recharge. To provide resolution and a common platform, a set of programs was developed to transform the data from raw well and irrigation files to a common cell-by-cell format. This common format consists of a set of files named ***yyyy.mm.xxx***, where the letters designate the year, month, and type of information respectively. The type of information is "pmp" for pumping, "rcs" for surface water recharge,

"rcg" for groundwater recharge and "rcc" for canal recharge. In addition, the file named **yyyy.xxx** is used to represent annual quantities and type of information respectively. For the annual quantities, "mi" is used to represent municipal and industrial pumping, "asw" is the surface water irrigated area, "agw" is the groundwater irrigated area, and "aco" is the commingled irrigated area. Volumes are always specified in acre-feet, and areas are always specified in acres.

Colorado – The Colorado groundwater input data consist of two databases. The well database specifies the location, county, appropriated acreage, and priority date for each well. The pumping database specifies the county totals for well pumping and the county-by-county groundwater irrigated efficiency. The **mkgw** program is then used to calculate cell-by-cell pumping, groundwater irrigation recharge, and irrigated areas. The program distributes pumping from the county to the model cells by assigning pumping proportional to the appropriated acreage of the active wells for that year. Pumping is distributed from the annual value to monthly values using a fixed proportioning. Irrigation recharge from groundwater is assigned to the same cells where the pumping occurs. The groundwater recharge is equal to the pumped amount multiplied by the return flow fraction, defined as one minus the irrigation efficiency. The appropriated acreage is used to calculate cell-by-cell groundwater irrigated acreage.

The Colorado surface water input data are also contained within two databases. The ditch database consists of the acreage per cell for each ditch system. The diversion database consists of monthly diversions for each ditch. Surface water irrigation returns are calculated as

the fixed percentage of the diverted amount as specified in the settlement agreement. The surface water return flow amount is distributed over the ditch acreage proportional to the acreage in each cell. The **mksw** program is used to perform this calculation. The surface water irrigated acreage is the sum of the ditch acreages for each cell. There are no commingled surface and groundwater irrigation applications modeled in Colorado.

Kansas – The Kansas groundwater input data consists of two databases. The well database specifies the location, county and irrigated acreage by year for each well. The pumping database specifies the total pumping for each county by year, the irrigation efficiency by county by year, and the annual to monthly distribution factors by county by year. The **mkgw** program is used to calculate monthly cell-by-cell pumping by distributing annual county totals to months using the monthly factors, and then to cells in proportion to the irrigated acreage for each year. For years that records indicate the well is not pumping, an irrigated acreage of zero switches off pumping in that well. The groundwater recharge from groundwater pumping is assigned in the same cell as where the pumping occurs. The groundwater recharge amount is computed as a percentage of the pumped amount, equal to one minus the irrigation efficiency multiplied by pumping, adjusted down for runoff and spray loss.

The Kansas surface water return flow calculation is performed exactly like the surface water return flow calculation in Colorado except for those lands in Kansas served by the Almena Canal that are surface and groundwater irrigated commingled land.

Nebraska – The Nebraska raw data consists of seven databases. They include the lands served exclusively by groundwater irrigation database, the commingled lands groundwater irrigated database, the lands served exclusively by surface water irrigation database, the commingled surface water database, the river pumpers database, the private canals database, and canal leakage database. Each of the first four databases specifies the annual volume of applied water and area over which it is applied on a cell-by-cell basis. The river pumpers database and private canals database supply only the annual volume by cell and the canal leakage database supplies the monthly volume by cell. The program **mknedat** is used to create the required monthly groundwater pumping files by distributing the annual cell-by-cell pumping to a monthly timestep using a fixed set of factors. The groundwater recharge is calculated as a factor of the pumped amount. This factor is a constant over the State of Nebraska, and is 30% until 1960 and then reduces linearly to 20% in 2000. The pumping and groundwater irrigation recharge are calculated in the same manner for commingled and exclusively groundwater irrigated lands. The total of both commingled and exclusively groundwater pumping is written to a single pumping file. The exclusively groundwater pumping acreage is stored to the groundwater irrigation acreage files. The commingled groundwater acreage is not used in this application since it is the identical acreage that is designated as surface water commingled acreage.

Surface water farm deliveries are specified on a land-by-land basis. For each land, the cell and appropriate canal system is specified. The return flows from each land are calculated as the delivered amount multiplied by a

system specific fraction. This fraction is specified in the FSS, and for most systems it is a constant with time, but for some systems the return flow fraction varies with time. The annual volume is accumulated for each cell and distributed to a monthly timestep using the same set of factors used to distribute the pumping. The irrigated acreage served exclusively by surface water is saved to the surface water irrigated area file and the commingled surface water area is saved to the commingled area file for the year.

River pumpers and private canals are specified as annual totals by cell. The return flow from these irrigation methods is calculated as a fixed fraction of the applied amounts and added to the cell-by-cell surface water return flows. The irrigated acreage is not considered.

The canal leakage database specifies canal losses on a cell-by-cell basis for every month and is simply copied to change the file format.

7. Stress Calculation

The Republican River Pre-Processor (**rrpp**) program is used to construct MODFLOW recharge and well pumping input files from these cell-by-cell files. The input files for each State are kept in a separate directory. The **rrpp** program reads the cell-by-cell monthly and annual files for all three States, calculates recharge from precipitation and outputs the resulting recharge and well pumping data sets as input to the MODFLOW program. A steady state step is used to establish the model initial condition at the beginning of the 1918 to 2000 transient simulation. There is no well pumping, irrigation recharge or canal leakage in this initial steady state. Therefore, the recharge consists only

of precipitation recharge. The rrpp program calculates the precipitation recharge for each year from 1918 to 1940 and then averages the recharge. Each cell is assumed to be only non-irrigated during this period.

The **rrpp** program is used to generate MODFLOW input files for both the historical or base run and the impact runs – "no State pumping" for each of the States and "no Nebraska import." The program reads a set of instructions from a parameter file. The NOPUMP instruction is used to switch off irrigation well pumping and return flows for a particular State as well as the M&I pumping. The MOUND instruction is used to switch off all surface water returns and canal leakage within the area in Nebraska designated as the mound area. A map of the mound area in Nebraska is provided in Appendix A.

Pumping is calculated on a month-by-month basis by accumulating the cell-by-cell pumping specified in the individual State files. If pumping is switched off for a State, pumping for that State is simply omitted. The total pumping for each month is then written to the MODFLOW well file.

Recharge from irrigation is calculated on a month-by-month basis by accumulating the cell-by-cell return flows from precipitation, surface water and groundwater irrigation recharge, and canal leakage. Surface water return flows are accumulated on a cell-by-cell basis for each State, except when the MOUND instruction is used, in which case the surface water return flows inside the designated mound area are omitted. In a similar manner, canal leakage is accumulated on a cell-by-cell basis for each State, except again the mound area is omitted when so instructed. Groundwater recharge is also accumulated on

a cell-by-cell basis for each State, except when the NOPUMP instruction is used, in which case the groundwater recharge for that State is omitted.

In order to calculate precipitation recharge, the irrigated area within each cell is accumulated as the sum of the groundwater, surface water and commingled area in the cell. When the MOUND instruction is used, the exclusive surface water acreage is not added within the mound area. Similarly when the NOPUMP instruction is used, exclusive groundwater acreage within the cell is not counted. Commingled acreage is always counted. If the total irrigated acreage within a cell equals or exceeds the number of acres in a cell, the entire cell is treated as irrigated. Otherwise the remaining acreage within a cell is treated as non-irrigated.

The annual precipitation for each cell is calculated by kriging the annual precipitation at a number of stations in the basin to the cell. For both the non-irrigated and irrigated fraction of the cell, the amount of recharge that corresponds to this precipitation amount is then calculated from precipitation recharge curves that correspond to non-irrigated and irrigated lands for the type of soil associated with this cell. The soil type and curves are specified in the parameter file read by the **rrpp** program. The resulting total recharge for the cell is then calculated as the product of the fraction of non-irrigated and irrigated lands multiplied by the respective recharge amounts. The total recharge from precipitation is then adjusted using a spatial multiplier to adjust the recharge amount for spatial variations in terrain. The resulting annual recharge amounts are then distributed to months using a fixed set of monthly factors.

The resultant total recharge is the sum of the precipitation recharge, surface and groundwater irrigation recharge, and canal leakage, appropriately adjusted to honor the NOPUMP or MOUND instructions. These values are written to the MODFLOW recharge file.

8. Phreatophyte Evapotranspiration

The MODFLOW evapotranspiration input file is generated by the **mket** program. This program calculates the monthly maximum evapotranspiration rate required by MODFLOW from four input files. The monthly phreatophyte evapotranspiration rate at the Akron, McCook and Red Willow climate stations is read from the first database. This rate is then multiplied by the phreatophyte area. The phreatophyte area is calculated from the present day cell-by-cell areas multiplied by a set of Sub-basin factors. The Sub-basin factors vary by year and hydrologic Sub-basin. Within each Sub-basin, the area is adjusted by the Sub-basin factor for that year. Basin factors were generated for the period 1938-1993. After 1993 the basin factors were assumed to remain at the 1993 levels. From 1935 to 1938, the basin factors were assumed to remain at the 1938 level. Although the basin factors were initially taken from the USGS, they were ultimately determined as calibration factors. However, no information prior to the catastrophic 1935 flood in the Republican River Basin is available. Since the flood regime of the basin changed with the construction of federal reservoirs in the 1950's and beyond, the present day phreatophyte growth is not representative of pre-development growth. Therefore the year 1950 was selected as a surrogate to represent pre-development phreatophyte evapotranspiration.

The evapotranspiration surface is set equal to the NED ground surface, and the extinction depth is set to a constant ten feet. The NED ground surface is adjusted in the stream package setup to provide for streams always flowing down gradient. In those cells, the evapotranspiration surface is set at five feet above the stream channel elevation. This offset is intended to represent the elevation of the stream banks relative to the incised stream channel and is a constant across the basin.

9. Streams and Reservoirs

The stream network previously generated by the USGS was adopted for this study. The streambed conductance, thickness and area were adopted verbatim. The **mkstr** program was used to adjust the streambed elevation to represent the more accurate NED data that became available after the original USGS work and to introduce reservoirs to the stream network.

The streambed elevation for a cell was calculated as the average of the minimum NED elevation for a cell and the upstream cells within the stream network. For headwater cells, the elevation was set equal to the average NED elevation in the cell. The stream network was then traversed in a series of operations designed to ensure that the stream network runs down gradient. Where the NED reflects present day reservoir stages, a linear interpolation from the cell above and below the reservoir was used to represent pre-reservoir stream elevations.

In order to model reservoirs as part of the stream network, each reservoir was associated with one or more stream segments and a set of model cells. At the particular month that a reservoir came into operation, that stream

segment was replaced by a set of reservoir cells with a conductance equal to one square mile in area, a hydraulic conductivity of one foot per day, and a thickness of ten feet. The reservoir segment of the stream network is isolated from the rest of the stream network by altering the tributaries array and an inflow into that segment is set to one million cubic feet per second. The stream elevation for each month is set equal to the middle of month stage for the reservoir. This arbitrarily large inflow ensures reservoir losses are not constrained within the reservoir segment. Since outflow from the reservoir segment is not transferred to downstream segments, the assignment of this inflow does not affect downstream computations. Note: the stream network must be specified for every stress period during which reservoirs are active because the reservoir stage changes from month to month. The specific yield was set to zero for those cells containing reservoirs because the reservoir storage change calculations are explicitly incorporated within the RRCA Accounting Procedures.

The HYDMOD package was used to extract stream flows and reservoir leakage at selected locations. A limitation of this package is that the number of reaches within a stream segment cannot change in order for the HYDMOD package to extract the flow at the correct location. Therefore, the **mkstr** program pads the reservoir segments of the stream network with "dummy reaches" to ensure that each segment contains the same number of reaches before and after the reservoir goes in. The dummy reaches can be identified as having a conductance of zero, which precludes any surface-groundwater interaction but ensures proper routing of flow and proper operation of the HYDMOD package.

IV. Calibration of Groundwater Flow Model

A. Purpose of Calibration

The purpose of calibrating the RRCA Model is to achieve an acceptable level of correspondence between model inputs, results and historical physical observations of the groundwater flow system in the Republican River Basin. The process of calibrating the RRCA Model also included the mathematical representation of the hydrogeologic framework, boundary conditions and hydraulic properties to reflect the physical characteristics of the Republican River Basin.

B. Calibration Targets

1. Water Levels

Groundwater levels have been measured throughout the Basin since the early 1900's, but the number of sites increased dramatically post-World War II. The source of groundwater level information used in the RRCA Model is the Groundwater Site Inventory (GWSI) maintained by the United States Geological Survey (USGS) in cooperation with all three States. The tenure of static groundwater level data ranges from a single-year measurement at a discrete location to a continuum of annual measurements that began in the early 1950's and continues to date at the same well. Groundwater levels are typically measured once each year, usually in the non-irrigation season when effects from irrigation pumping are minimized. The RRCA Model is calibrated to a groundwater level dataset that contains a total of 350,233 water level records at 10,835 different sites. The GWSI dataset was converted from latitude/longitude to an X-Y coordinate system. The entire dataset, including one-measurement water levels, was

used in model calibration except for wells that were determined by the representative State to be clearly erroneous. The dataset and well hydrographs depicting observations and predictions are provided in electronic format in Appendix A.

2. Baseflow

Hydrograph separation is a technique that partitions the amount of surface water and groundwater that is measured as total streamflow at a river gaging station. Determining the component of total streamflow that is contributed by groundwater (also called baseflow) requires professional expertise and judgment. The hydrograph separation analysis used in this application is referred to as the Pilot Point method. This procedure was adopted for application in this groundwater model since it combines the benefits of graphical baseflow analysis with the computational efficiency afforded by electronic spreadsheets. Daily streamflow information for one, or multiple years, is easily tabulated in a Microsoft Excel® electronic spreadsheet. Daily hydrographs are subsequently plotted using the graphics package. The analyst performing the baseflow separation uses the tools available in the electronic graphics package to select pilot or turning points that signify the baseflow component in the total amount of streamflow measured at a river gaging station. A significant contribution of the graphics and computational package afforded by Microsoft Excel® is the flexibility to easily change the assignment of each pilot or turning point upon comparative review with other nearby streamflow hydrographs or in collaboration with another analyst. The analyst may change one or multiple pilot points using the click-and-drag tool to another turning point and instantly

recalculate the amount of baseflow for a defined period of time – from a month up to decades.

For the RRCA Model, sixty-five (65) independent baseflow analyses were performed and adopted as calibration targets. Annual and monthly baseflow estimates for each analysis are provided in electronic medium in Appendix A.

C. Comparison of Model Calculations to Targets

The RRCA Model calculations match the representative baseflow and water-level targets to a reasonable and acceptable degree. For the baseflow evaluation, the RRCA Model results were evaluated in juxtaposition on a graphical format with the accepted baseflow quantifications for 65 different stream reaches. Based upon professional judgment, the model results reasonably match the trend and magnitude of the actual baseflow condition at the various locations.

Hydrographs showing the physical observations and model predictions were generated for all groundwater wells with measurements. Professional judgment was again used to evaluate the accuracy of the measurements and the comparison to model predictions, with greater weight being given to wells with a consistent measurement set and longer periods of record. In consideration of the magnitude and complexity of the model domain, the RRCA Model generally matched the observed water-level targets. The comparative evaluation of model calculations to physical targets based upon professional judgment, as opposed to a statistical assignment, is an acceptable method for a mathematical model with the magnitude and complexity inherent within the Republican River Basin.

D. Calibrated Parameters

Calibration parameters are physical, climatic, and/or aquifer properties that can be adjusted to so that the mathematical representation of a groundwater model better represents actual conditions. Selection of final values for calibration parameters requires consideration of the match between model outputs and calibration targets, and whether such values are reasonable considering geologic, climatic, and other conditions in the Republican River Basin. Calibration parameters may vary in a spatial context to reflect different physical and/or geographic conditions. The two principal calibration parameters used in application to the RRCA Model are hydraulic conductivity and precipitation recharge.

1. Hydraulic Conductivity

Hydraulic conductivity may be defined as the measure of the ease in which water can be transmitted through a porous material, i.e. flow through an aquifer. The hydraulic conductivity values applied in the model are based upon professional expertise and vary across the model domain. Hydraulic conductivity parameters were refined and statistically distributed throughout the model domain during the calibration process. Hydraulic conductivity values were specified at a set of user-supplied points, approximately one per county. These point values were distributed to every cell in the domain using logarithmic kriging. The point values were varied during calibration using a combination of professional judgment and automated calibration using a parameter estimation program.

2. Precipitation Recharge

The amount of precipitation that percolates into the groundwater aquifer is dependent upon different soil characteristics and the amount of precipitation. Three general soil classifications were identified and distributed throughout the Republican River Basin: coarse, medium, and fine. As part of the model calibration, the STATSGO Soil Type 832 that was originally classified as "fine" was reclassified as "medium" to better differentiate precipitation recharge in the mound area in Nebraska from the rest of the model domain. In addition, the alluvial valleys were treated as distinct soil groups, with one group for the tributary alluviums and one for the alluvium along the mainstem. Recognizing the amount of precipitation that recharges the groundwater aquifer increases in proportion with precipitation, a set of two curves was developed for each of the three soil classifications. One curve is for irrigated lands and the other for non-irrigated lands. The Y-axis for each curve is inches of recharge from precipitation and the X-axis depicts the total amount of precipitation each year.

Lesser calibration parameters that are used to further refine the groundwater model include:

3. Spatial Multipliers

The Spatial Multiplier has a value of 1.0 throughout the model domain except in the mound area in Nebraska where the value is 1.5. A map of spatial multipliers with associated values is provided in Appendix Q.

4. Steady-State Multiplier

For the period of 1918 to 1940, the long-term average recharge is not fully indicative of all conditions in the model domain, primarily in the western area. A steady-state multiplier of 0.75 was applied to the average of the 1918-1940 recharge period throughout the Republican River Basin.

5. Phreatophyte Potential Evapotranspiration Rate

The rate is indexed to the McCook and Red Cloud, Nebraska and Akron, Colorado climate stations. The annual potential evapotranspiration rates were linearly interpolated from west to east across the model domain. To improve the ability of the model to match baseflows, all phreatophyte evapotranspiration rates were adjusted by a factor of 2.0. For specific Sub-basins, a second factor ranging between 0.03 and 1.12 was applied. The location of the phreatophyte areas and distribution of potential evapotranspiration are provided in Appendix R.

6. Saturated Thickness

Applied within the RRCA Model to improve the model performance, the saturated thickness in any given model cell was adjusted to a minimum of 10 feet. The saturated thickness is based upon average values for the period 1940-2000 and was kriged across the model domain between known data points. The distribution of saturated thickness is provided in Appendix S.

7. Transmissivity

The adjustments to hydraulic conductivity and saturated thickness described above were made during the calibration procedures and resulted in a distribution of transmissivity that is provided in Appendix T.

E. Model Output

The RRCA Model is fully operational and calibrated to represent the physical and hydrogeological characteristics of the Republican River Basin to a reasonable degree. The RRCA Model reasonably matches the trend and magnitude of groundwater levels and stream baseflow targets distributed throughout the Republican River Basin, without significant bias in any region or hydrologic characteristic. The RRCA Model is calibrated to a sufficient degree that depletions from groundwater pumping and accretions from imported water from the Platte River System to the Republican River are quantified and assigned to prescribed streamflow reaches that are in accord with the RRCA Accounting Procedures.

The RRCA Model calculates the amount of groundwater depletions from well pumping as the difference in streamflows using two simulation runs of the model. The "base" run is the simulation with all groundwater pumping, groundwater pumping recharge, and surface water recharge within the model study boundary for the period 1918 to the current accounting year "on." The "no State pumping" run is the simulation run with the same model inputs as the base run with the exception that all groundwater pumping and pumping recharge for that particular State is turned "off." The amount of recharge from precipitation is recalculated by converting all groundwater-only

irrigated land to non-irrigated land. The amount of depletions charged to each respective State is the difference between the "base" run and the "no State pumping" run. In a similar manner, the "no Nebraska import" run is the simulation with the same model inputs as the "base" run with the exception that surface water recharge from irrigation and canal leakage that is associated with Nebraska's Imported Water Supply is turned "off." The amount of recharge from precipitation is recalculated by converting all surface water-only irrigated land to non-irrigated land and the Imported Water Supply Credit is the difference in stream flows between these two model simulation runs. For commingled lands, defined as receiving irrigation water from a combination of surface and groundwater supplies, there is no switch or conversion from irrigated to non-irrigated lands because it is assumed any deficit from one supply source will be replaced by the other. Therefore, while the surface or groundwater return flows may be removed in a no pumping or import simulation run, the derivation of recharge from precipitation remains unchanged for commingled lands.

An output of the model is baseflows at selected stream cells. Changes in the baseflows predicted by the model between the "base" run and the "no State pumping" model run are considered to be the depletions to streamflows, or groundwater computed beneficial consumptive use due to State groundwater pumping at that location. The values for each Sub-basin include all depletions and accretions upstream of the confluence with the Main Stem. For Sub-basins with reservoirs and the Main Stem, the model's output totals the depletions and accretions above and below each federal reservoir and in the reservoir reaches. The values for the Main Stem include all depletions and

accretions in stream reaches not otherwise accounted for in a Sub-basin. The values for the Main Stem are computed separately for the reach above Guide Rock, and the reach below Guide Rock. For subsequent years, the RRCA Model will be extended to include new hydrologic, pumping, climate, and other annualized datasets. The data will be compiled and exchanged in accordance with the RRCA Accounting Procedures.

For illustrative purposes, impact tables that quantify the depletion of groundwater well pumping and imported water supply accretions by stream reach are provided in Appendix U for the period 1981-2000.

V. Conclusions

The RRCA Model fulfills the requirements of the FSS to develop a groundwater model for use by the RRCA to aid in the administration of the Republican River Compact. The RRCA Model quantifies the amount, location, and timing of streamflow depletions caused by groundwater well pumping and the accretions to streamflow from imported water across the model domain on an annual basis. The RRCA Model provides the required output information in an acceptable format to describe the amounts and timing of said groundwater pumping depletions and imported water accretions that are necessary for application within the prescribed annual RRCA Accounting Procedures. The RRCA Model calibration represents the physical and hydrogeological characteristics of the Republican River Basin to a reasonable degree. The use of specific methods or computational procedures within the RRCA Model does not necessarily mean that any party represents or accepts them to be the best or only method

for purposes other than that which is applied in the RRCA Model. The RRCA Model will be used as is, with only annual updates to the appropriate data files and necessary modifications to pre-processor programs required to accommodate modified future data formats, but without recalibration, until such time as the RRCA approves any changes. The RRCA may consider revisions to the model as set forth in the FSS.

APPENDIX A

RRCA Model DVD

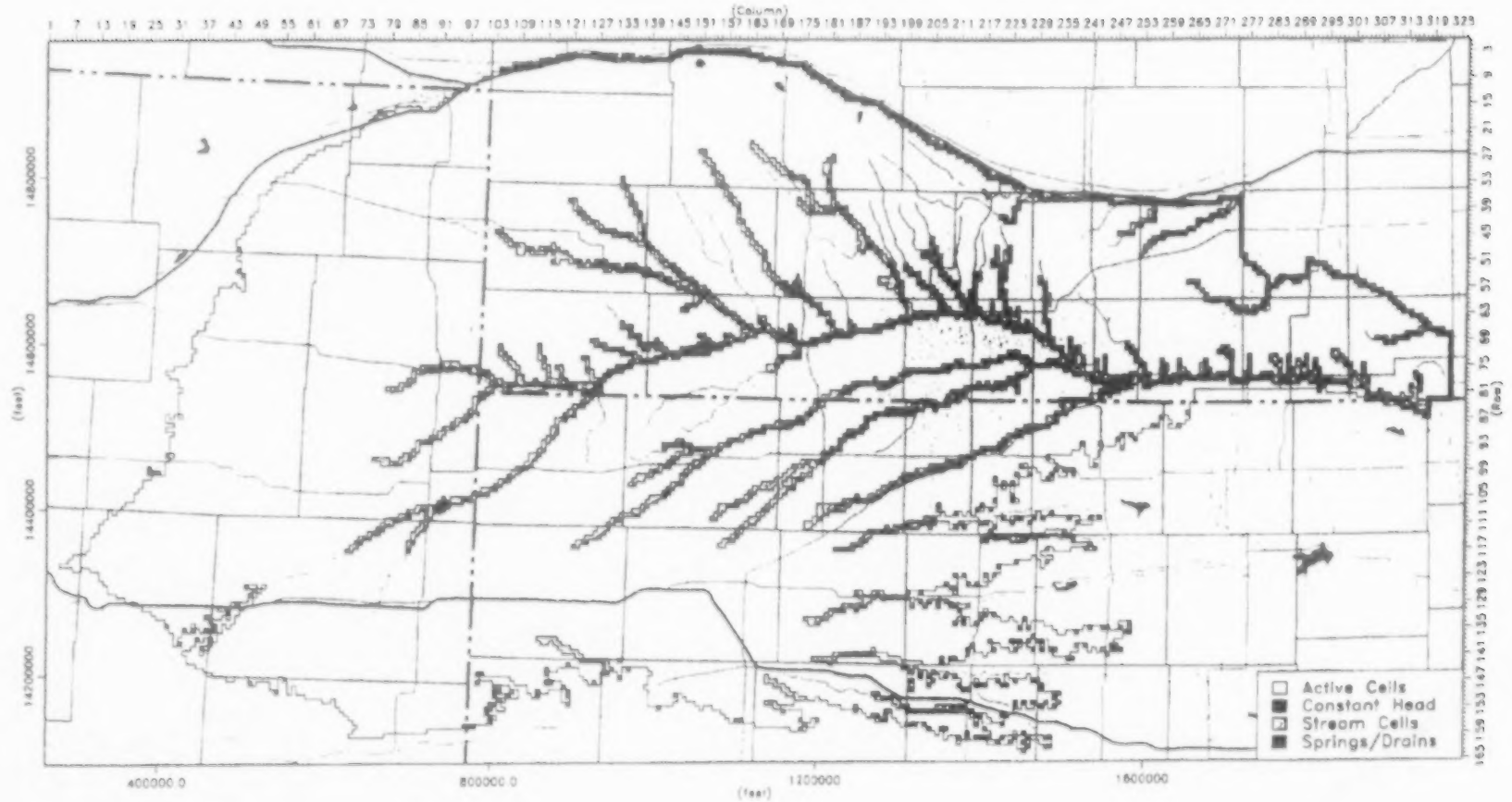
A1

(See inside back cover)

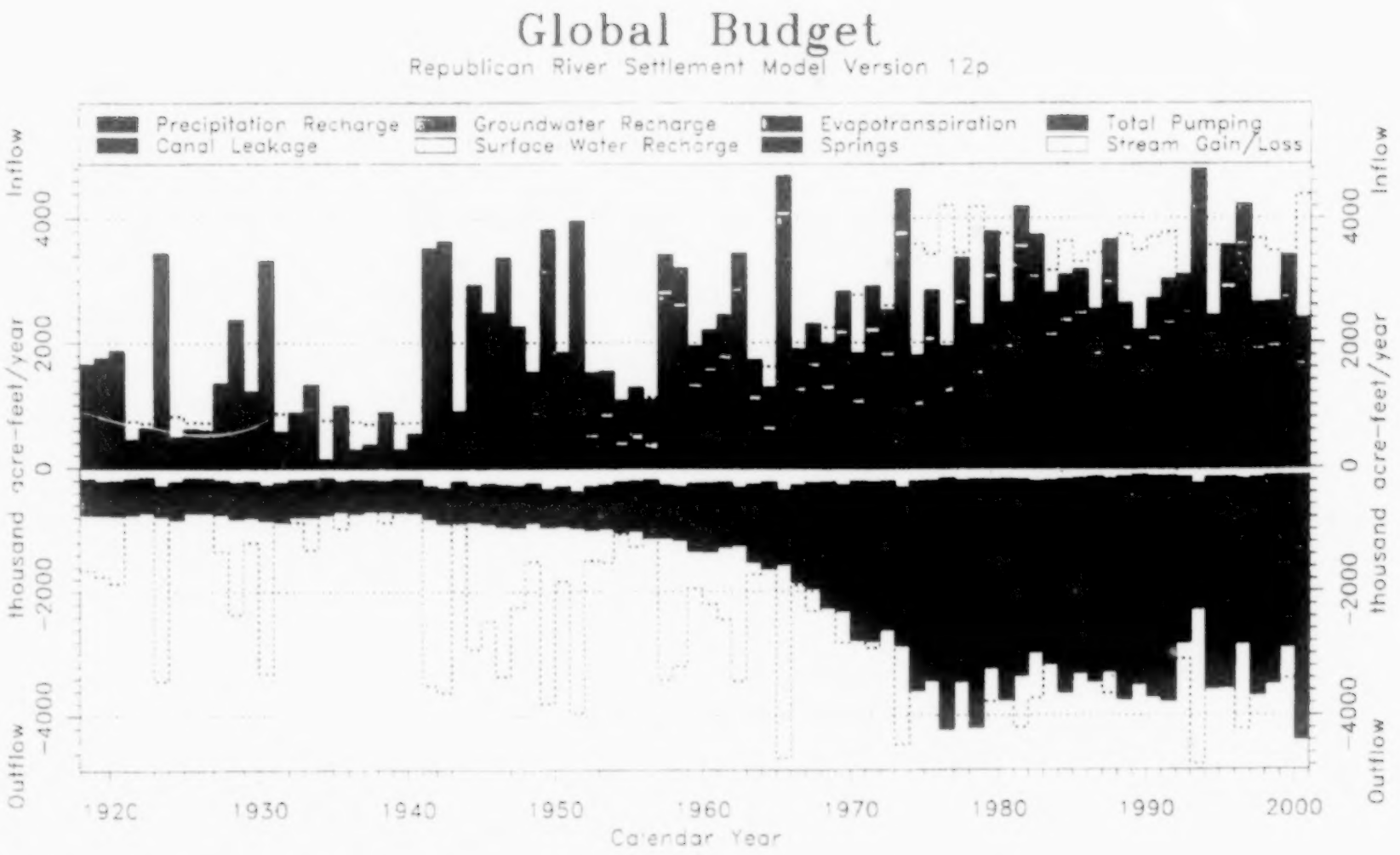
APPENDIX B

MAP OF RRCA GROUNDWATER MODEL DOMAIN

RRCA Ground Water Model Domain



APPENDIX C
GLOBAL WATER BUDGET


Global Budget
Republican River Settlement Model Version 12p
Precipitation Recharge
Canal Leakage
Groundwater Recharge
Surface Water Recharge
Evapotranspiration
Springs
Total Pumping
Stream Gain/Loss
Inflow
Outflow
thousand acre-feet/year
4000
2000
0
-2000
-4000
1920
1930
1940
1950
1960
1970
1980
1990
2000
Calendar Year

APPENDIX D

PUMPING ESTIMATES FOR EACH STATE

Appendix D
Pumping Estimates for each State

Pumping for Irrigation in Colorado -- The State of Colorado employed an eight-step procedure to estimate groundwater pumping:

1. Total acres irrigated by surface and groundwater is estimated for each county based upon data from the respective County Assessor's Office for the area contained in the RRCA Model boundaries. This data was supplemented with irrigated acreage reported by the National Agricultural Statistics Service (NASS).

2. The acreage irrigated by surface water is identified from the County Assessor's Records.

3. The acreage irrigated by groundwater is calculated as the difference between the total acreage and the acreage irrigated by surface water.

4. The maximum farm efficiency for center-pivot sprinkler irrigation and flood irrigation is estimated for each year.

5. The percent of acreage irrigated by center-pivot sprinkler is estimated for each county for each year.

6. The crop water requirement is estimated for each county using the Hargreaves empirical formula calibrated to the Penman-Monteith method for reference crop evapotranspiration. The crop mix for each county is determined from NASS county-level crop statistics. The effective precipitation is estimated using the procedure outlined in Irrigation Water Requirements, Technical Release No. 21, United States Department of Agriculture, April 1967 (Revised September 1970). The crop

irrigation requirement is calculated as the total or potential crop water requirement minus the effective precipitation.

7. The calculated crop irrigation requirement was reduced by two (2) inches per year to account for the gain in antecedent soil moisture from winter and spring precipitation.

8. Pumping for each county is estimated as the product of Irrigated Groundwater Acreage multiplied by the Net Crop Irrigation Requirement multiplied by Fraction of Crop Irrigation Requirement satisfied. The Fraction of Crop Irrigation Requirement satisfied was estimated from available pumping records. The pumping for each county is then divided by the maximum farm efficiency. The maximum farm efficiency is a weighted average based on the amount of sprinkler and flood irrigation. County pumping estimates are distributed to groundwater model cells using the well capacity for irrigation wells.

Pumping for Irrigation in Kansas – The State of Kansas developed estimates of pumping within the model domain using a combination of water use report data and estimates based on irrigated acreage and crop demand for years prior to the availability of reliable water use reports. The amount and location of pumping was taken from the water use report data for the period of 1989-2000. The estimated crop demand was compared to the water use reports for this period and a relationship developed, by county, to estimate pumping prior to 1989. Pumping estimates for 1940-1988 were made on a countywide basis.

The following procedure was used by the State of Kansas to estimate irrigation pumping for the period of 1989-2000: Kansas state officials have received water use

reports from water right holders since 1957. In 1989, the Kansas Division of Water Resources (KDWR) was given additional enforcement authority and resources to require, obtain, and review water user reports of all water right holders. As a result, for the period 1989-2000, Kansas relied on the water use reports as its basis for estimating irrigation pumping. The water use report includes the total metered quantity or hours of operation, pumping rate, irrigated acreage, and crop type. Water users with meters are expected to report metered quantity; while those without meters report hours of pumping and diversion rate. Each water use report received by KDWR is reviewed for accuracy and completeness. All wells in the alluvium of the Republican River and its tributaries have been metered since 1998.

The State of Kansas completed a comparison of pumping reported for metered groundwater wells against non-metered users. For the period 1989-2000, the KDWR and the Kansas Water Office published a series of annual reports entitled *Kansas Irrigation Water Use Tables*. The series summarizes Kansas' water use data in a number of ways, including the contrast of metered and un-metered reported use. The data is tabulated by region, including each of the five Groundwater Management Districts (GMDs) and areas outside the GMDs within western, central and eastern Kansas. The statistics contrasting metered and un-metered water use were tabulated for the Northwestern Kansas GMD No. 4. In addition, statistics for Western Kansas GMD No. 1 and Southwest Kansas GMD No. 3 were tabulated for comparative purposes.

For GMD No. 4, for the period 1989-2000, reports of un-metered pumping averaged 21.6% greater than metered pumping on an acre-foot/acre basis. For 1994-2000,

the period when the percent metered within the GMD was greater than 10%, the average reported pumping for un-metered points of diversions is 17% greater than for metered. In 1992 and 1993, the un-metered reports were 38% and 39% higher than metered reports, respectively. For GMD No.1 and GMD No. 3, similar differences between metered and un-metered reporting are evident in the early years of the record. However, with increasing metering in each of these GMD's, metered and un-metered reporting merge toward near-identity by the end of the 1989-2000 period. The conclusion of this analysis is that non-metered reported use for 1989-2000 was higher than metered reported use. Based on the results of this analysis, the pumping from the non-metered reports was adjusted downward by 10%.

Net groundwater pumping was determined by multiplying the total pumping by an estimated irrigation efficiency (which includes evaporative spray loss and runoff loss). Recognizing that the type of irrigation method has changed over time, Kansas assumed that all irrigation was flood irrigation until 1959, with an efficiency of 65%. Center pivots (85% efficiency) and other sprinklers (75% efficiency) were in use starting in 1960, and Low-Energy Precision Application systems (LEPA, 90% efficiency) use began in 1990. For 1960 to 1993, the proportion of center pivot and other sprinklers was interpolated from zero in 1959 to the value reported in the Kansas Water Rights Information System in 1993. The same procedure was applied to LEPA for the period 1990-1993. Flood irrigation was assumed to comprise the remainder for each year to bring the sum percentage of groundwater irrigation methods to 100%.

The following procedure was used to estimate irrigation pumping for the period 1940-1988:

1. Determine the potential evapotranspiration (PET) for the irrigated area and crops determined for the study area:
    a. Compute reference ET with the Penman-Monteith method for years when detailed climate data are available.
    b. Develop calibration coefficients for the Hargreaves method to use prior to availability of detailed weather data.
    c. Compute crop PET for study period.
    d. Compute effective precipitation during the growing season, using the procedure outlined in Irrigation Water Requirements, Technical Release No. 21, United States Department of Agriculture, April 1967, (Revised September, 1970). Over-winter soil moisture accumulation was separately computed, using values proposed by the State of Nebraska, and deducted from the CIR to obtain the seasonal irrigation requirement.
    e. Determine crop distribution from county level crop statistics.
    f. Compute crop irrigation requirement (CIR) on a unit basis (inches per acre).
2. Compile a history of well development, including location, date and source. The main data source is the Kansas water use database.
3. Compile irrigated area estimates, based on county crop statistics, previous studies and water use reports.
4. Compute the volume of crop demand for irrigation (CIR) on a county-wide basis, and use this as an initial estimate of the net irrigation pumping.

5. Compare the estimated net irrigation pumping to the water use reports for 1989-2000.

6. Use the comparison of estimated to reported pumping to develop a factor to multiply by the crop demand to estimate the actual net pumping for 1940-1988.

Water use reports collected prior to 1989 were reviewed to evaluate the levels of pumping indicated by these records. Although these records do not provide comprehensive pumping figures for the study area, there is a sufficiently large population of data to assess relative levels of pumping. The data showed that pumping rates (in gallons per minute – gpm) have steadily declined since 1970 to current levels. The data also indicate higher pumping amounts per well in the 1970s. The steady decline in pumping rates and amounts was corroborated by discussions with Kansas water officials. Probable reasons for the declines include reductions in well pumping capacities and changes in irrigation practices. Based on this evaluation, it was concluded that the 1989-2000 level of pumping used to establish the relationship between CIR and pumping was constrained by available pumping capacity and current irrigation practice to a greater degree than pre-1989 pumping. The reported pumping rate (gpm) was used as an indicator of this trend over time. The average pumping rate for a county in a given year (1970-1988), was compared to the 1989-2000 average to obtain an annual ratio. The 3-year running average was used to smooth these values to provide annual adjustment factors to apply to the pumping computed from the fraction of crop demand indicated by the 1989-2000 data. The 1970 factor was used for 1940-1969.

Pumping for Irrigation in Nebraska – The State of Nebraska computes the volume of pumping based on

electrical energy use, pumping power requirements, and estimated well discharge based on a correlation to the flow rate recorded at the time of well registration. The method uses a uniform time of operation for wells supplied by a Public Power District. The total volume of water pumped is distributed on a county-level basis for the number of wells and acres irrigated by each respective county within the Republican River Basin. Groundwater is distributed at a uniform irrigation depth within each county for sole-source groundwater irrigated lands and a different uniform depth for commingled lands that receive surface water and groundwater as supply sources.

The total volume of groundwater pumped per county (Vp) is the sum of volume pumped for sole-source groundwater irrigation (Vg) and the volume pumped for commingled lands (Vc). The volume of groundwater pumped for sole-source lands (Vg) is the product of the number of acres of irrigated lands served exclusively by groundwater (Ag) and the depth of groundwater applied to sole-source lands (Dg) in units of acre-inches/acre divided by conversion factor of 12 inches/foot. In a similar manner, the volume of groundwater pumped for commingled lands (Vc) is the number of commingled acres (Ac) multiplied by the depth of groundwater applied to commingled lands (Dc) divided by 12. Since commingled lands received both groundwater and surface water, the average depth of groundwater applied to commingled land is a fraction (f_g) of that applied to lands served exclusively by groundwater (i.e., $Dc = f_g \times Dg$). The ratio of the depth of groundwater applied to commingled land to the depth applied to sole-source groundwater irrigated lands was 0.5 for most counties.

Appendix D Pumping Estimates Colorado

Year	Cheyenne	KitCarson	Lincoln	Logan	Phillips	Sedgwick	Washington	Yuma
1918	0	0	0	0	0	0	0	0
1919	0	0	0	0	0	0	0	0
1920	0	0	0	0	0	0	0	0
1921	0	0	0	0	0	0	0	0
1922	0	0	0	0	0	0	0	0
1923	0	0	0	0	0	0	0	0
1924	0	0	0	0	0	0	0	0
1925	0	0	0	0	0	0	0	0
1926	0	0	0	0	0	0	0	0
1927	0	0	0	0	0	0	0	0
1928	0	0	0	0	0	0	0	0
1929	0	0	0	0	0	0	0	0
1930	0	0	0	0	0	0	0	0
1931	0	0	0	0	0	0	0	0
1932	0	0	0	0	0	0	0	0
1933	0	0	0	0	0	0	0	0
1934	0	0	0	0	0	0	0	0
1935	0	0	0	0	0	0	0	0
1936	0	0	0	0	0	0	0	0
1937	0	0	0	0	0	0	0	0
1938	0	0	0	0	0	0	0	0
1939	0	0	0	0	0	0	0	0
1940	126	0	0	194	782	0	244	0
1941	94	0	6	112	448	0	614	130
1942	102	0	7	136	897	0	594	166
1943	142	0	8	223	1511	0	679	256
1944	152	0	7	201	1368	0	953	229
1945	322	0	5	103	667	0	1089	147
1946	478	0	7	176	1170	0	1449	336
1947	429	433	7	170	1172	0	2880	564
1948	301	1630	408	216	1525	0	3380	958
1949	322	2982	462	151	1940	198	2428	2747
1950	625	4206	802	178	2841	236	3243.4	2954.8
1951	857	3530	413	119	1489	393	3183	3578
1952	812	6085	671	246	4011	758	4824.4	8122.8
1953	1011	8487.8	811	195	3447	601	5928.9	8881.5
1954	1051	13328.4	784	202	4059	634	6381.1	12029.5
1955	1333	26796.5	958	192	4189	626	4870.8	14303
1956	1868	43798.2	780	229	5485	1035	6898.4	21908.1
1957	895	29841.3	458	448	5429	1314	6726.8	20337.5
1958	710	31060.3	462	348	4849	900	6319.3	18786.2
1959	971	54319.2	819	453	5822	1306	7106.2	29828.8
1960	1128	48567.4	845	483	6379	1316	7370.8	23129.1
1961	915	51574.4	807	386	5887	1063	6151.9	20822
1962	1238	53378.2	580	350	5563	1018	6679.4	17526
1963	1738	90814.1	780	599	8531	1516	9111	30809.4
1964	2327	129033.8	918	756	17763	1940	9919	52291.1
1965	2347.4	79503.3	485	445	15726	1084	9788.2	46574.3
1966	3015.3	180724.9	883	506	22790.5	1158	14022.8	71347.7
1967	3091.8	161988	714	450	34581	1833	18214.3	140716.8
1968	4265.3	200982.2	979	1818	56647.7	4144	24471.8	171711
1969	3551.8	217486.3	987	1650	50858.9	6036	25907	214575.8
1970	4721.9	238606.5	1153	1958	76191.2	8827.8	27786.8	242008.7
1971	6838	252894	1218	1486	66387.9	6273	32982.9	283157.1
1972	7018.4	216619.8	1080	1712	67134.1	8836.1	29980.8	242300.8
1973	8708.4	250188.5	1179	2719	77226.9	11055.3	33788.4	224427.7
1974	14388.9	318352.9	1741	7209	121147	31228.2	51141.8	381441.8
1975	14882.1	280367.1	2140	7853	112870.3	33831.3	47428.5	381339.2
1976	19485.2	329229.9	2447	9008	136485.9	41178.8	57132.7	415334
1977	17711.3	277824.3	2095	7944	116934.8	38198.1	67097.1	382532.3
1978	17735.9	288977.4	2336	10002	148311.6	48002.7	58078.7	461778.2
1979	18238.2	221489.2	1645	7197	110527.5	34158.4	48228.8	395826.8
1980	16113.4	343365.8	2088	8771	128998.8	41046	56423.9	380083.4
1981	15230.8	268250.9	2121	7307	109630.5	34388.5	52432.2	384808.5
1982	14079	189123.2	1577	5482	83114.8	26188.3	42561.7	280388.7
1983	14788.2	167891.3	1662	6385	94099.9	29886.3	42004.8	298084.3
1984	14798.8	224138.1	2135	7782	107713.3	34079.3	41045.8	385797
1985	14102.7	184184.5	1573	7587	105838.4	30877.7	41537.7	298091.8
1986	13412.8	219180.1	1961	7338	99587.1	30288.8	47158.4	304889.8
1987	13885.8	200054.7	1817	7083	100064.9	31026.2	42131.3	358982.9
1988	13278.5	230850.9	2078	7714	107816.8	33863.4	51890.1	399880.5
1989	11388.1	222118.5	2067	6328	88063.8	27902.1	47908.8	367374.9
1990	12378.4	230867	1955	7480	103701.3	33411.8	41257.7	322618.8
1991	13092.7	201308.3	1925	8880	102771.8	32136.4	54418.9	258002.8
1992	14074.8	210283.4	2104	8517	90525.1	28989.1	48548.7	284888.5
1993	16368	208258.2	1855	5188	70179.1	23074.1	47035.3	281548.8
1994	15444.8	234581	2089	9229	126009.7	39802	56147.1	337778.8
1995	14302.2	192651.7	1773	6759	87521.5	30412	42925.2	293804.1
1996	14048.3	210628.2	1913	3588	50343.2	16812.2	41129.8	256781.6
1997	13807	210688.9	1988	7107	104258.9	33008.8	48646.1	301518.8
1998	14515.4	197073.8	1782	6806	89641	29837.8	57890.3	347082.4
1999	14441.8	186178.8	1779	5789	79479.2	26239.4	37115.8	293224.3
2000	18094.4	267000.4	2348	10000	126386.4	41728.8	62570.8	371568.8

Appendix D Pumping Estimates Kansas

Year	Cheyenne	Decatur	Gove	Graham	Jewell	Logan	Norton	Phillips	Rawlins	Sheridan	Sherman	Thomas	Trego	Wallace
1918	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1919	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1920	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1921	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1922	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1923	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1924	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1925	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1926	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1927	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1928	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1929	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1930	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1931	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1932	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1933	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1934	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1935	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1936	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1937	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1938	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1939	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1940	1136.1	752.3	0	0	0	0	135	171	176	564.7	278	252	0	0
1941	1234	383.8	0	0	0	0	91	129	117	310	278	243	0	0
1942	2175	621	0	0	0	0	89	134	144	410.2	304	272	0	0
1943	3230	703.9	0	0	0	0	125	163	158	480	321	286	0	0
1944	3122.7	391.8	0	0	0	0	69	119	117	267	242	224	0	0
1945	3340.7	582.5	0	0	0	0	120	162	119	418	214	262	0	0
1946	4249	624.6	0	0	0	0	130	168	181	459.3	251	299	0	0
1947	3764	642.9	0	0	0	0	97	137	142	446.3	443	240	0	0
1948	3281	555.1	0	0	0	0	101	152	125	366	452	532.9	0	0
1949	3124	493.8	0	0	0	0	80	114	119	356	786	499	0	0
1950	3705	810.4	0	0	0	0	147	283	583	564.5	1280	505.9	0	0
1951	2328.8	363.4	0	0	0	0	69	192	309	321.3	796.9	585	0	0
1952	4661	852.1	0	0	0	0	270	398	711.9	791.5	4142	1336.9	0	0
1953	4094.4	761.9	0	0	0	178	173	748	1192	1122.5	4657.5	1287	0	0
1954	7361.5	1122.8	0	393	0	226	1064	1816.2	1443.6	1476.5	6171	1351.9	211	189
1955	8731.4	1948.5	312	563	0	248	1389.1	3879.6	2256.6	3646.3	10569.9	3112	187	197
1956	12202	3059.3	916	833	699.1	288	1747.8	5311	3405.6	9037.3	18801.1	9708	631.9	457
1957	12224.2	3029.1	589	466	323	267	1321.2	3870.4	2926.5	8461.9	17242.6	6804.5	342	324
1958	13742.2	2992.2	713.9	526.1	315	352	1383.2	4255.6	2984.5	9676.6	20513.2	7963.2	563	330
1959	16916.2	4238.7	1111.1	794.1	415	452	2060.6	6048	4109.9	14357.6	22280.8	11596.4	713	340.7
1960	22414.3	4965.3	1079	854.9	313	403	2047.1	4963.5	4988.4	14532.2	28401.2	11136.9	760	394.7
1961	17569.6	5327.6	654	700.1	427	567.9	2206.8	5442	3703.6	11145.2	20570.8	10736.5	162	278
1962	13444.1	3333.5	1075	880.1	447	417	1725.1	3667	2491.7	11420.7	25456.3	8842.2	669	269.4
1963	26337.1	6384.7	1748	1155	452	926.7	2122.8	5867	4899.2	16223.9	40831.3	13277.5	1068	360.7
1964	37992.4	5867.9	2583.7	1434.9	409	2820.3	3085.8	7457.7	5818.2	29080.9	62527.7	23795.9	1410.9	586.9
1965	30187.5	4035.2	1446	1290	409	1672.5	2152.5	3773	4633.8	16290.3	58785.1	16037.4	581	570.5
1966	41655.8	6121.4	4517.5	2405	556	2487.2	2895.2	6123.6	8678.8	28420.9	73431.3	23942.8	1160.9	1098
1967	45827.7	8996.9	6179	2009	453	3874	1912.5	3302.6	8068.1	33208.9	79619.7	38696.8	925	1002
1968	51311.2	6178.4	6408	2680.3	256	6507.2	1338.6	2663.6	8865	37803.1	101926.6	35433.7	975	1654.5
1969	54804	9721	8964.1	2449	343	6580.9	2184.8	3437.4	9176.6	50262.1	108264.6	43199.2	1307	1528.2
1970	61117.1	10879.8	10890.9	2830	474	10866.8	2924.2	5351.4	10881	66069	135239	50233.6	1560	2148
1971	64611.3	10365.8	15231.5	3836	520	12603.6	5966.8	7667.1	13160	81263.8	143600	62210.8	2159.2	2253.2
1972	53213.4	8416.4	15840.7	4206.1	417	10456	7647.7	7739.5	9209.8	73735.1	105014.7	61402.9	1384.9	2303.8
1973	66006.1	16810.9	17686.9	5590.1	372	12528.2	12981.9	7354.9	19074.1	93374.1	133113.3	85046.2	1567.2	3089.1
1974	68595.3	14724.6	26064.9	6548.1	639	11340.5	12239.1	14219.6	15493.2	120448.4	160254.2	91339.7	3018.7	5019.8
1975	66737	12110.7	17585.9	4612.1	321	10747.5	5654.6	4810.8	15876.5	84786.7	161579.5	71924.2	2016	4952.3
1976	84360.6	18963.7	33164.1	10328.1	411.8	16069.6	11926	12139	18785	161922.2	224080.4	175689	2474.8	7280
1977	66040.8	10806.4	18502.8	6667	981.9	9814.2	9072.4	7439.4	11992.1	106922.3	169634.7	96796.2	1921.2	5778.1
1978	76345.9	16035.1	21401.8	12968.6	1430.9	14112.2	11053	6858.9	18015.5	133007.9	202349.7	152435.2	1804	5742.2
1979	52008.2	7578.8	13274.8	8026.4	1767.5	8503.1	7352.2	4837.3	14154.2	91340.8	131651.8	96237.1	1703.2	4144.9
1980	45784.9	15863.9	18128.5	8064.7	1560.9	11179.3	16126.5	11752	11989.1	134149.9	126614.5	130619.4	1542.8	3714.8
1981	54106.7	15731.9	17914.6	8127.4	942.2	11992.5	6278.4	5362.3	11266	106812.9	180218.5	136468.9	2040.2	6007.3
1982	45155.4	13946.1	19479.8	9032.5	728.1	8809.7	8827.3	6030.5	14213.2	95987.9	108590.1	85137.8	2204	3036.5
1983	50151.2	16676.3	18348.8	8343.8	857.2	12893.1	7863.2	5899.7	15270.4	93884.3	135966	95271.7	2338	2929.5
1984	43793.3	17328.7	20831.2	10249.2	1295.2	10675.9	15743.4	7615.4	15011.6	128928.3	127522.9	115672.6	2285.2	3342.9
1985	42304.2	16069.4	18087.4	13451.1	942.8	8879.1	12803.6	7716.8	12821.1	109074.8	113327.5	112783.5	2110.2	3364.6
1986	53941.5	14350.2	21726.9	11420	1136.7	10158.2	11345.7	7867.3	16442.3	107093.1	138024	165222.6	1516.8	3719.7
1987	51404.8	9333.6	17028.7	7433.7	1035.9	5583.2	9257.4	7049.2	15688.4	85246.5	108467.3	109724.2	1589.8	3131.6
1988	53192.7	7994.1	17314.6	7455.6	1267.7	9382	10265	5412.4	18006.1	103421.9	112039	114440.7	2151	2925.1
1989	58642.5	14964.7	17511.2	8306.3	945.4	9473.5	11909.5	8192.5	18259.9	111863.6	134230.8	134713.6	2279	3710.1
1990	56449.1	13238.7	15437.5	9224.5	1089.4	8904.7	10699.9	7439.8	19325.9	95161.1	139964.5	129307.2	2332	3416.2
1991	50870.4	13063.8	16778.7	10284.1	1339.7	9213.1	10995.3	6349.1	17189.2	97371.5	121332.8	118948.3	1942.2	3018.1
1992	36867	4308.7	6750.9	4573.3	289.1	5897.7	4409.7	3779.1	8309.5	48089.5	81805.4	56967.1	656	2651.8
1993	39774.8	3800.4	5323	2143.6	116.1	4978.3	3926.5	2733.2	9770.5	34981.6	80321.3	64786.4	433	2627.2
1994	49668.9	7871.4	13003.8	6684.5	1029.5	8595.8	7045.7	5089.8	14183.9	76119	103625.9	97124.7	1632.8	3456.7
1995	36861.5	11570.8	12662.7	7714.7	1258.2	6338.3	8433.3	5535.9	14957.3	79004	89074.2	89993.2	1209	2704.5
1996	44605.2	8173.1	9849.6	6843.6	1196.3	6075.7	5094.5	3023.9	12297.3	67184	105803.4	89922.1	1077	3124
1997	54443.6	11631	10245.1	7819.9	1065.9	7181.2	7973.7	5347.6	17515.2	67269.3	120769.6	100178.1	1458.9	2545.2
1998	46618.5	11786.9	10706.2	6100	909.9	6082	7462.8	4462.9	15409.3	56273.1	111048	90677.7	1496	2740.5
1999	45690.5	8148.2	9352.3	6622	1077	5866.3	6296.4	4831.8	12081.1	57860.7	96174.9	76958.9	1514	2711.9
2000	60728.6	16301.7	13709.4	10266	1403.5	7578.1	7867.9	3999.6	21993.1	91260.2	131885.1	123856.7	2094.4	4023.6

ndle D	Pumping Estimates				Nutrients																			
	Adams	Buffalo	Chase	Clay	Dawson	Deuel	Dundy	Franklin	Frontier	Furnas	Gosper	Hall	Hayes	Hitchcock	Kearney	Keith	Lincoln	Nuckolls	Perkins	Phelps	Red Willow	Webster
1918	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1919	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1920	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1921	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1922	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1923	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1924	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1925	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1926	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1927	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1928	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1929	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1930	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1931	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1932	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1933	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1934	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1935	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1936	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1937	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1938	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1939	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1940	133.8	521	1164.3	0	6435	1346.3	838.6	745.9	276	836.1	1508.8	491.1	437.1	2386.7	6100.9	3238.4	[illegible]	988.1	213.8	1439.8	1638.8	416.8
1941	82.3	318.3	1135.5	69	4648.3	1078	491.8	449	188.8	618.4	1322.9	446.1	288.8	1711.8	3884.5	2708.8	5448.4	813.8	253.4	4367.1	985.4	219.8
1942	67.7	262.8	939.3	54.8	4882.6	883.1	433.8	484.6	214.8	420.1	1307.1	442.3	353.2	2346.6	3521.3	[illegible]	6168	82	288.5	4081.8	1667.8	156
1943	69.5	347.4	1785.8	71.8	6850.4	1387.2	670.6	676.3	248.7	747.9	1871.8	646.1	288.8	2845.2	4875.8	4254.3	7784.8	1145	448.8	5758.1	1811	238.6
1944	69.6	445.8	1605.3	71.1	4639.3	1080.8	608.8	675.4	188.1	612	1648.8	675.1	288.4	1787	6788.1	3870.3	4478.2	988.8	358.6	5468.2	1081.8	211.7
1945	69.6	621.1	2388.5	71.1	6772.8	2378.8	1436.1	780.3	188.8	922.8	1639.8	816.3	408.2	2888.8	6811.7	6521	[illegible]	91.8	445.4	5838.4	2018.5	178.8
1946	75	891.8	1673.7	88.1	6882.8	1848	1122	774.3	288.8	1138.1	1833.3	1037.8	534.1	2878.7	7838.7	6888.8	7838.8	1103.3	288.1	5413.3	1848.1	238.3
1947	464.8	3.1	2391.1	0.3	88	2737.4	1888.8	1157.8	338.3	1388	48.1	2222.1	1888.8	8186.8	1488.3	8788.3	10647.8	888.8	401.1	181.7	2815	888.8
1948	481.3	2.1	2852.4	0.4	87.3	2774.1	1881	1817.2	418.3	1408	38.7	2888.8	888.2	8832.8	1137.3	10877.8	[illegible]	878.1	811.3	138.1	3482.8	834.8
1949	857.4	6.2	3008.1	1.2	83.8	2887.7	1888.4	1248.3	838.1	1818.2	84	2021	888.3	7308.8	888.3	11818.8	1873.2	1087	881.1	143	2421.1	804
1950	834	7.8	3412.8	2.2	83.3	1808.8	84.2	888.2	871.7	113.8	27.8	308.4	888.8	1082.8	888.2	10818.8	2178.2	70.3	887.7	47.2	483.8	188.8
1951	888.7	8.8	3417.2	1	78.1	828.2	132.8	167.4	83.8	83.8	12.2	180.2	153.3	888	117.4	8388.3	2383.4	30.1	848.7	23.8	814.2	128.8
1952	1248.1	14.3	4718	3.8	232.2	2188.8	888.7	818.8	188.8	188.8	48.2	324.7	888.1	1284.8	844.3	14888.8	[illegible]	132.1	1748.8	88.3	1088	481.1
1953	1828.1	88.1	8118.8	88	882.8	1828.8	781	888.8	134.3	238.8	88.8	878.8	823.7	1827.8	2884.3	12384.1	18812.7	182	2388	788.8	1788.8	881.3
1954	2831.8	187.8	7882.7	88.4	784.8	2488.4	2048	1272.8	888.2	831.8	482.3	1337.8	1488	3823.8	3848.8	16721.3	[illegible]	784.8	3718.8	1248.4	3478.8	888.4
1955	2278.8	124	21348.8	888.8	2843.8	3883.1	7237.3	488.1	1818.1	2874.8	2308.8	5482.4	1888.8	7888.8	1888	7843.3	[illegible]	3778.8	1472	3188.1	15188.1	18788.8
1956	3781.4	128.4	24873.8	483.4	3721.3	3857.2	8138.5	5888.8	3114.8	4123.3	3115.1	7883.8	2134.2	8812.4	11378.8	8287.1	[illegible]	3422.8	2218.8	24118	22188.3	18172.7
1957	3882.4	834.3	14378.8	708.8	8178.3	1783.3	8438.8	7883.8	3128.8	7886.8	4883.8	8488.8	1834.8	7481.2	24078.8	10882.2	18121.8	4788.3	2838.3	24048.7	3828.8	8273.8
1958	2382	388	12281.2	488.4	5438.8	2181.8	8881.1	5323.8	2388.3	5488.8	3084.3	8184.7	1838.2	7478.2	17048.8	11888	[illegible]	1838.4	1888.8	18788.4	2817.8	2778.4
1959	7788.8	1138.4	23384.3	1387	12842.2	4488	1488.1	10827.4	7838.8	13738	8418.5	14874.4	3838.2	15488.7	34818.8	24841.8	38188.8	8738.8	4277.8	32328.8	8801.1	8148
1960	7448.4	1231.2	24884.8	1348.8	14232.2	4888.8	15388	10438.4	8878.7	8842.2	8842.1	10832.2	3887.7	14734.8	33428.4	28187.1	38882	8321.2	8202.3	27714	7887.7	8788.8
1961	8548.8	888.4	8878.8	1788.2	11437.8	2384.8	13148.8	10888.4	4482.7	8882.8	8488.8	10278.8	3832.8	10438.8	34548.8	14753.2	13878.8	7118.1	2887.2	28332.3	8478.8	11884.2
1962	4888.2	477.8	8378.8	884.8	8847.5	1728.8	7333.4	7188.2	2438.8	4388.8	2882.8	8188.7	2382	8287.7	23288.8	88733	7284.8	887.1.3	1884.7	18788.4	3882.8	878
1963	8738.4	1888.8	18423.1	1887.8	18834.8	3238.1	17088.8	14841.1	8888.1	13818.3	8878.8	14328.8	7348	18378.8	48878.2	28732.4	22178.1	7807.8	3883.8	42148.3	17788.7	14888.8
1964	13888.8	1377.4	22088.3	2388	18148.8	5588.8	17388	13388.8	8888.8	13338.4	7784.8	14818.8	8241.8	18822.8	44883.3	31788.8	[illegible]	11883	3847.8	38827.1	10227	17888.8
1965	10834.7	828.2	15838.8	1801.3	10888.5	3848.3	14882.8	13388.8	8888.1	8814.3	8477.7	10841.8	7038.8	17487.2	44338.8	17187.2	13828.3	8371.2	3438.7	38815.7	8187	13812.3
1966	10458.8	1438.8	18848.8	1820.8	17188.4	2878.1	14838.8	8881.8	8888.8	8812.1	8112.1	11138.8	8818.3	18878.3	47888.1	18840.8	[illegible]	13388.3	4448.2	38888.1	10888.4	18887.8
1967	18828.8	1217.8	38871.8	2877.3	14781.8	8881.8	18881.8	17881.8	14338.3	8888.7	7711.8	23788.8	8888.8	21383.8	18123.2	11842.8	8888	18848.8	21477
1968	18858	1883.3	81417.8	8328.8	18888.1	8788.8	32427	17848.8	27278	24881.1	12388.1	33718.4	13174.8	32818.8	88134.7	84818.3	28478.4	14837.2	24888.8	88182.1	23421.4	23888.4
1969	24881.7	1811.1	101388.4	4812.8	25488.2	10187.8	82778.4	32888.8	41888.8	31178	18888.8	48887.8	28188.7	40888.7	103888.7	71242.8	88284.8	18718.1	38818.4	111448	32884.3	38844.1
1971	28888.4	2813	84428.1	8327.8	28823.3	8888.4	88828.8	38302	42888.8	31731.4	23827.1	47347.7	27821.7	37888.3	118817	43484.1	38474.8	17888.8	25181	111841.8	34181.8	32832.7
1972	18888.8	1847.2	88817.8	3417	38888.1	8488.7	48283.8	31184.7	82178.8	31818.3	27384.7	48888.4	23888.1	38127.8	88833.8	41477	41878.8	18442.2	28878.8	103888.7	38818.2	18771.4
1973	23372.7	1788.7	108777.7	4088.2	24883.8	8188.2	38884.3	38481.3	88418.8	38848.8	27888.2	53488.8	23188.8	32882.3	113387	48238.7	48881.3	11717	38488.4	122388	37223.7	23272.8
1974	32288.7	2888.8	148488	8877.8	38838.7	7887.7	87173.3	44882.8	72888.8	38887.8	41888.8	88181.4	28883.8	40888.4	138044.8	88438	78482.8	18448.1	88708.8	154814.8	82348.8	34888.8
1975	28284.8	*2383.7	103248.3	4857.1	38881.8	8827.8	78782.3	44882.8	78878.8	38484.8	43082.8	88288.8	33818.2	43828.8	138812.1	81387.7	78878.8	14212	88388.8	182118.8	88818.8	32437.7
1976	38888.4	2822.7	218823.8	8888.8	42884	7188.1	103888.8	84388.3	87488.8	84118	88888.1	88281.8	41848.8	48188.8	178182.8	88178.8	108884.4	18888	88888.7	208888.8	82884.8	48888.1
1977	21388.8	2217	188847.7	2848.8	32181.8	8288.8	88888.8	47884.3	88872.7	44137.8	44148.4	72888.8	28844	38488.3	118488.8	82188.3	[illegible]	8718.1	8874.8	144818.3	81788.8	33284.8
1978	88178.8	2817.8	288878.4	3724	38488	8784.8	124888.4	84884.2	88218.7	81772.8	81388.1	88878.3	82382.8	138888.4	82188.7	11424	138488.3	113888.7	88888.2	178488.8	83848.8
1979	22878.4	1888.2	191437.7	3818.8	38147.7	8231.2	87877.3	43823.8	47848.4	38274.8	88428.8	48848.7	38818.8	38888.3	183384.7	87882.8	88881.8	113888.8	88723.8	118488.4	88848.3	28883
1980	31825.4	3871.1	204188.2	3878.4	48443.2	8478.4	87881.3	87848	78288.1	88848.2	88281.8	78848.8	37184	47548.8	188188.8	88212.1	122888.8	14418.8	88772.3	178812.8	81888.1	38881.8
1981	21353.8	1838.7	178888.8	2434	27248.8	8084.8	78828.7	88818.7	48888.8	27112.4	32888.8	43817.2	28883.7	34422.8	188388.8	87884.2	88282.1	8881.8	78888.4	128888.3	78883.3	22741.8
1982	18881.8	2183.8	138888.3	2381	33543.8	4388.8	87818.2	42381.7	84888.1	33848	88838.8	82518.8	28318.4	32837.3	8818.2	48887.1	88838.7	8488.4	88878.8	114888.3	42128.2	21388.7
1983	28284.4	1871.3	188188.4	3373.8	38308.4	8488.7	88843.8	82384.1	84483.2	31388.8	88838.7	88228.1	82888.4	41833.3	88838.8	111728	77827.1	11888.1	88818.8	128881.3	83373.8	28388.3
1984	28878.4	2842.1	221181.8	3888.8	31784.8	8888.8	113411.3	88128.8	88887	33888.4	88238.1	82888.4	41833.3	88838.8	111728	77827.1	118822.1	11881.7	11818.8	128881.3	83373.8	28388.3
1985	23882.3	2518.8	183425.8	2874.8	38438.8	8234.8	107158.3	84818.3	88417.8	40881.2	48238	88877.3	38438.2	48342.8	138878.8	78488.8	121871	8387	88888.8	144283.4	84887	24888.8
1986	28288.3	2188.7	188883.2	2787.8	34841.8	8888.8	88488.3	88878.8	88381.3	88888.8	47848	88388.2	88478.8	48788.2	148282.8	88878.3	88788.8	8718.7	82184.7	188818.1	47472	28881.2
1987	42448.1	2814.3	288348.8	4878.1	44888.7	8488.2	88881.7	88838.7	88887.7	48881.7	81888	84488	88388.8	42388	288841.1	74188.8	123888.7	17431.8	88888.2	222888.8	88831.1	48188.8
1988	38888	2744.8	283882.4	4438.8	38488.8	8138.8	82387.4	87848.2	87738.2	47738.8	88434.2	78488.1	87888.3	43888.3	187238.2	74881	118888.8	11778.8	88138.8	178888.3	88848.8	31188.8
1989	27888.8	2388	238888.8	3888.8	88838.4	8188.1	88877.4	88878.8	88888.1	48288.8	87888	75421.3	48882.7	51887.8	188888.7	88388.4	147888.3	8888.2	88488.8	184888.8	81878.7	28787.1
1990	24888.8	2888.8	214781.8	4813	84757.4	8287.4	113218.8	88872.4	88811.2	84288.8	84884	87818.2	41811.7	44478.4	238278.2	87828.8	188888.8	17813.8	88888.8	188137.8	88128.8	87487.2
1991	18483.8	2283.7	174888.8	1878.2	34188	8128.4	74288.3	88138.3	42841.2	38888.1	37738.8	88812.8	88487.8	27887.4	118788.8	88478.8	87888.8	7118.2	88888.8	132888.7	88812.4	17881.2
1992	8823.8	887.1	14388.8	828.2	8881.7	8878.8	83888.8	8888	4818.1	8748.7	8882.8	11488.8	17704.1	13888	81488.7	42281.1	88888.2	3488.4	81888.8	48888.1	8278.7	8488.8
1993	24888.4	2327	284281.2	2788.8	33742.3	7873.4	117844.2	87884.8	71888.8	88482.8	88887.8	88188.8	42147.2	48282.8	138188.8	88731.8	138878.8	10821.7	13888	147888.8	83881.1	28488.7
1994	38843.4	3388.8	288348.4	4288.4	48883.8	7448.2	111888.8	88488.8	78881.7	44484.8	88288.7	78488.1	47888.3	44381.4	203748.4	91887.8	138788.7	18883.8	12888.8	172382.7	88884.8	31188.8
1995	23288.8	2188.7	188144.2	2887.7	32488	8871.2	83802	88814.2	42213.8	17875.3	31188.3	38884.7	28383	38477.1	121388.8	87878.4	88488.8	10788.8	88888.7	128877.8	87484.8	28888.1
1996	24888.8	2888.8	238758.8	3438.4	51888.7	8814.1	103881.3	88788.4	88887.8	44188.8	88178.4	78888.1	51838.2	48818.8	188432.8	88888.8	141888.8	14788.4	88888.8	152888	88128.8	38288.7
1997	24882.8	2884.2	238383.1	2445.8	42481	7128	148158.3	84788.8	72843.8	38488.7	48781.8	88178.3	58837.2	52047.8	148884.1	88428.2	138872.3	10838.1	12188.7	151842.8	88388.8	28818.3
1998	38208	2418.4	181823.8	2811.3	32888.8	8882.8	82844.7	88888.4	14388.3	38888.4	38843.4	88700.2	28888.8	12827.4	72882.8	88883.8	13888.7	8888.1	12887.4	88288.7	31537
1999	41878.8	4887.4	288118.8	4384.8	84888.1	1888.1	181823.8	188837.8	83884	42474.3	87811.8	75388.8	78887.8	82838.8	2288838	188888.2	88218.8	18437.2	18887.8	227888.8	77184.7	48818.7

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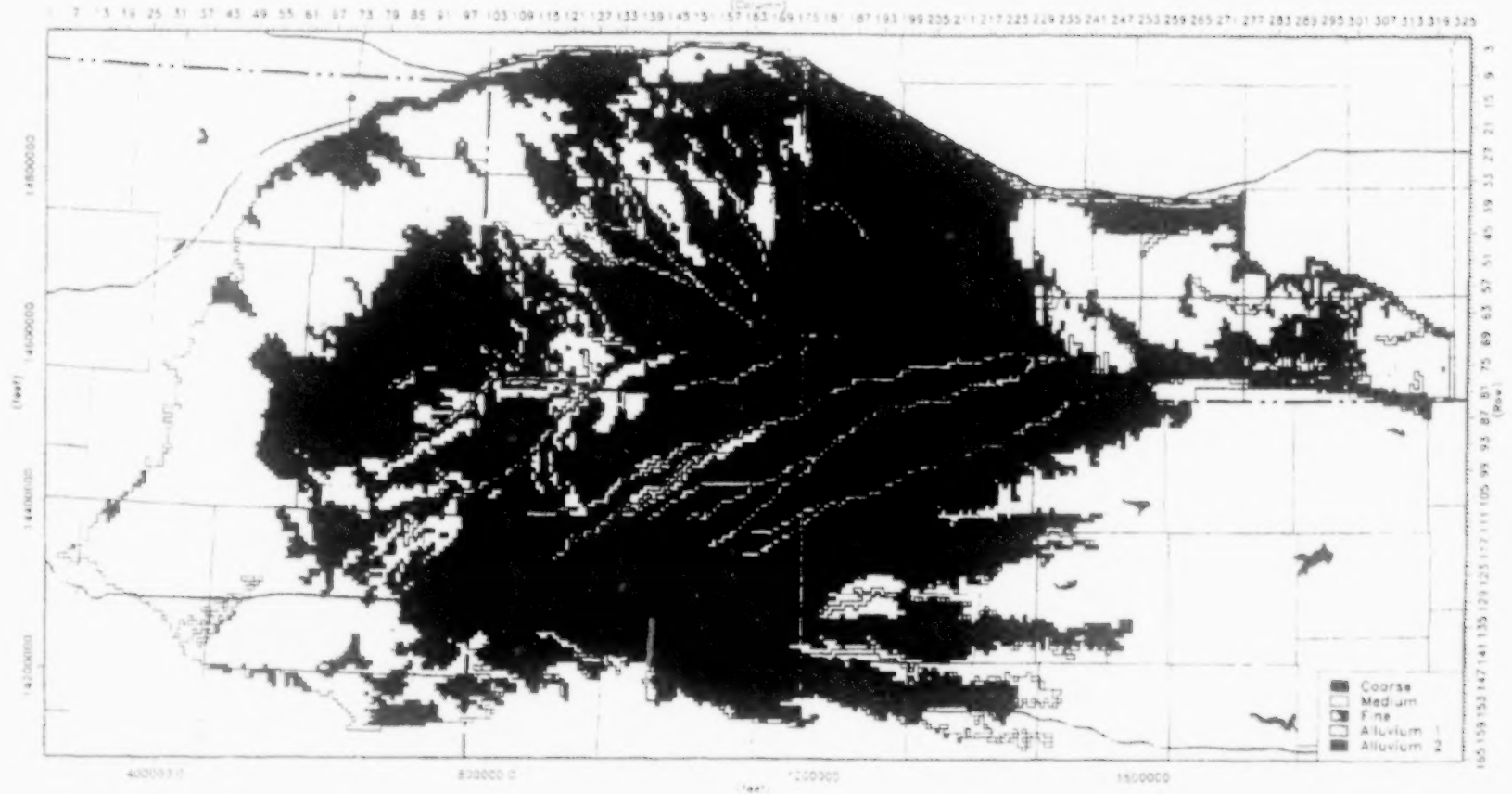
APPENDIX E

DISTRIBUTION OF SOIL CLASSIFICATIONS

Distribution of Soil Classifications

Republican River Settlement Model Version 12p

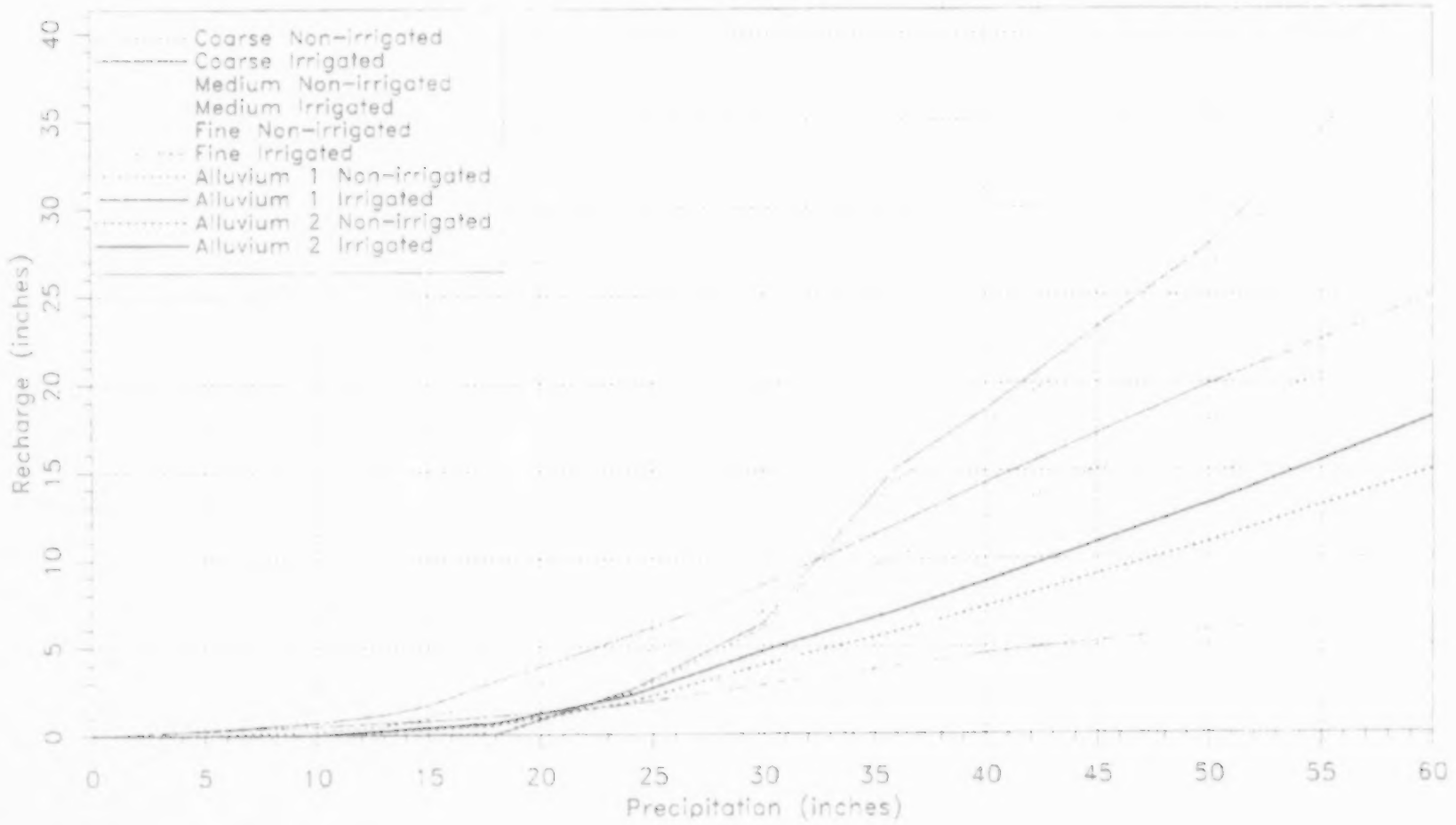


APPENDIX F

PRECIPITATION RECHARGE CURVES

Precipitation Recharge Curves

Republican River Settlement Model Version 12p



APPENDIX G
RECHARGE FROM PRECIPITATION

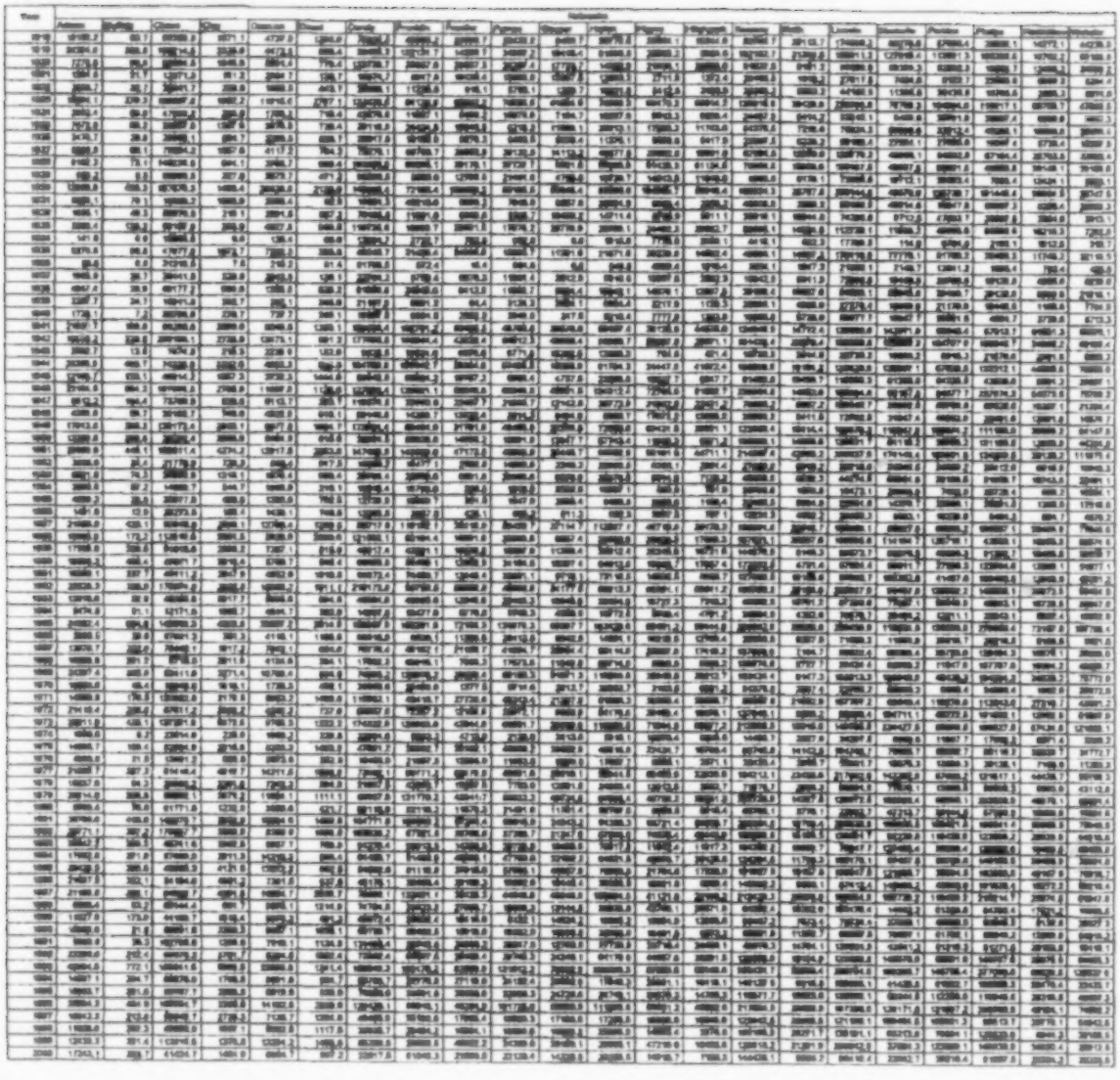
Appendix G Recharge from Precipitation (acre-feet per year)

Year	Colorado							
	Cheyenne	KitCarson	Lincoln	Logan	Phillips	Sedgwick	Washington	Yuma
1918	27866.0	75803.9	28646.8	28386.8	38688.2	34587.9	87688.5	187801.7
1919	4879.8	22715.0	3326.4	1942.8	2808.1	8549.7	16190.6	21993.6
1920	18374.7	103682.5	29291.0	44130.9	66452.1	37108.4	141475.6	354719.5
1921	10627.8	39228.8	7104.1	2148.8	2878.0	3310.9	13022.7	38421.9
1922	7085.7	40084.3	10341.8	11542.1	18423.1	13258.7	48792.1	107421.6
1923	38300.1	159987.4	88736.9	33908.5	24888.9	88364.8	163801.5	172871.2
1924	458.8	7722.3	116.2	3938.0	9331.2	18580.8	6382.3	38872.0
1925	463.0	9297.1	82.0	3142.2	6448.3	15009.1	3642.0	25088.2
1926	1862.8	27282.0	10688.2	15867.1	12712.2	14980.8	65782.5	92983.5
1927	4188.4	31080.9	10668.2	19298.6	28395.7	22470.6	68644.6	151708.9
1928	18917.8	107212.9	11368.2	18827.6	56608.5	34467.8	53285.5	265210.5
1929	5618.8	80780.5	19746.8	27869.0	36782.5	19718.8	146347.6	238655.2
1930	30366.3	182012.0	23822.5	28751.9	49843.9	61301.1	86620.5	243877.2
1931	271.7	3360.9	80.0	808.3	1406.2	1228.9	2801.3	13840.0
1932	426.0	8730.4	212.0	18661.2	50422.3	21969.1	31402.5	204780.5
1933	8172.2	67382.0	14493.8	24133.9	31893.7	27833.3	77270.8	186730.0
1934	276.6	2084.1	188.3	2098.0	3220.6	2243.2	8143.2	24811.8
1935	378.8	12856.9	558.6	8065.0	8198.4	6363.2	41986.3	73389.0
1936	255.2	4487.7	41.0	1095.2	21898.1	4064.6	2981.1	94936.3
1937	296.1	4122.4	81.5	1305.0	3388.0	2537.4	3325.9	28649.2
1938	3386.8	36003.1	182.8	8706.2	31735.1	18828.8	13850.9	157937.0
1939	1196.0	8859.0	96.9	2377.9	8984.3	7866.8	3681.3	38697.1
1940	1822.7	9801.8	796.8	3288.8	7179.2	6603.8	13049.0	46201.7
1941	18721.4	106970.8	7561.7	37251.9	107068.9	54358.5	87795.7	383461.9
1942	12793.7	86810.6	14694.3	30124.8	102022.9	38307.1	104442.0	380054.4
1943	4140.0	20883.1	694.7	1481.3	3037.3	2071.4	7150.4	31956.1
1944	9730.7	57038.8	1164.2	8268.7	26828.1	19077.0	19170.9	143411.9
1945	14737.4	110853.3	19749.8	34129.7	48061.4	40214.0	103837.5	256288.3
1946	983.9	22251.8	111.4	9431.0	26182.4	23771.9	11960.1	121232.9
1947	12473.4	82982.3	7155.6	11803.5	61090.9	9820.0	48915.8	267171.7
1948	8448.2	22716.0	125.9	1453.9	8669.8	8868.9	4778.4	80646.2
1949	10715.2	116291.1	28671.2	57335.7	94800.6	39188.3	220800.9	443738.6
1950	886.7	10278.9	328.4	7237.8	11086.6	9108.4	21786.4	81364.6
1951	6832.9	58069.8	1916.3	32587.4	94333.5	74796.3	80362.4	241584.8
1952	1746.8	11625.8	1538.3	8458.0	8125.8	17453.5	17170.3	49730.9
1953	604.2	3164.6	258.3	14470.8	23940.8	24087.4	12084.9	49407.3
1954	230.8	1678.7	108.0	3984.8	18664.1	4786.7	3174.6	28916.7
1955	483.8	5204.4	312.1	13810.2	21810.2	18832.5	16862.8	44648.1
1956	231.8	2942.8	137.1	4411.4	7729.8	13634.0	3746.6	19923.3
1957	32504.2	182262.6	18476.4	16796.4	28148.5	28080.2	69547.0	223626.8
1958	44803.0	214999.2	28925.3	33616.5	81875.0	60333.1	83693.7	349896.9
1959	4308.4	10307.8	282.0	10336.0	38306.5	14101.4	11891.2	82035.9
1960	9276.8	54375.9	1087.4	3820.8	13998.7	9386.1	12383.1	106695.3
1961	11928.8	58433.8	10730.1	17719.0	31118.4	24180.2	63801.2	193763.1
1962	6100.1	49999.8	860.8	13661.4	61871.9	21725.5	36046.7	337093.0
1963	565.5	10891.6	249.6	5662.4	14004.1	10123.0	13712.8	88803.5
1964	370.1	5492.7	178.7	2920.6	4859.7	3980.7	6144.0	28366.8
1965	19687.9	143688.5	8058.5	23237.4	56094.5	59459.0	48099.6	256421.1
1966	6314.3	37764.6	5966.8	26250.3	86714.3	37259.8	38656.8	230376.5
1967	2229.0	27384.7	1953.5	17019.6	46953.5	19327.6	38658.8	141245.9
1968	404.8	11087.8	167.0	2472.8	5166.2	3675.7	7534.3	51977.0
1969	7906.3	20215.9	843.9	5472.6	20120.3	16306.3	8232.4	82275.1
1970	3313.0	13425.3	343.7	3662.3	12364.6	6256.7	8909.2	62794.6
1971	2891.4	23130.5	290.0	13412.5	58703.1	33112.9	11760.3	122549.2
1972	2509.0	19980.0	249.0	7331.3	31801.7	16166.0	10018.1	100607.0
1973	8038.9	58379.9	8446.0	38125.3	87020.9	38906.6	112304.7	364507.7
1974	869.1	10983.1	222.3	1886.3	8140.9	2666.8	7642.0	56220.1
1975	1340.3	20018.0	461.3	18327.1	28132.9	31863.4	31733.8	111419.2
1976	826.3	8732.9	263.7	1956.1	7188.3	2983.5	6429.0	39848.4
1977	1217.6	16707.8	246.1	20136.8	61866.5	40494.8	14584.4	163201.0
1978	2826.0	19871.6	841.9	2157.2	6068.1	3361.9	14069.2	47586.6
1979	9079.5	76300.6	12320.9	24078.3	40196.2	27725.8	78006.2	182806.3
1980	8227.1	70845.8	8224.9	14041.7	46077.5	13988.0	53384.8	287715.1
1981	10038.9	72248.8	8674.1	38010.6	97770.9	48362.2	77271.9	307882.3
1982	8198.2	69978.8	4879.3	27342.9	102066.8	35469.5	58886.5	381073.2
1983	8002.9	84618.6	7963.3	18823.8	31518.2	18277.1	55250.4	158166.8
1984	1291.2	18666.0	1666.1	13046.7	23023.5	9621.8	43298.9	93987.9
1985	9029.9	59301.1	11838.8	17846.9	28090.8	18410.0	65170.7	178945.5
1986	1614.5	16777.9	378.8	8096.8	18797.4	10318.7	12808.1	77802.8
1987	9632.7	89801.3	11884.0	30802.9	51122.3	51397.2	73005.0	196809.7
1988	5172.8	34885.5	8230.3	24822.8	43844.5	33623.5	60862.9	143692.2
1989	10677.0	34369.0	8173.3	6374.3	22340.5	9223.8	19983.4	91371.0
1990	4852.1	43936.4	9887.1	19031.5	25218.9	20620.8	68008.0	198032.5
1991	7646.9	83876.4	3082.3	16757.2	48356.7	24088.7	44488.4	291486.5
1992	11486.0	72329.8	8402.9	22703.2	37898.4	49853.1	81416.5	207824.4
1993	3104.8	31444.4	273.9	8480.1	46756.2	22538.9	19982.7	172426.9
1994	7826.1	48798.8	2421.5	3089.1	13480.4	6881.4	23322.4	143324.1
1995	30482.1	201935.5	83788.1	28008.1	48369.2	20945.8	20486.1.9	327633.9
1996	8336.4	53482.2	9837.5	82530.3	147848.5	82839.6	98248.3	263240.8
1997	8048.8	28842.7	818.6	4570.4	13277.7	16280.2	15224.3	88038.4
1998	18038.1	103483.5	8424.6	10808.9	31944.9	21467.4	27280.8	128008.4
1999	27990.2	200054.1	43888.2	35715.8	72346.0	38338.3	144166.5	306999.0
2000	1519.2	28130.0	423.8	2817.6	7606.5	6297.4	13884.7	74082.4

Appendix C Recharge from Precipitation (acre-feet per year)

Year	Kansas													
	Cheyenne	Decatur	Gove	Graham	Jewell	Logan	Norton	Phillips	Rawlins	Sheridan	Sherman	Thomas	Trego	Wallace
1918	33974.7	24513.5	11031.1	22248.2	1773.9	5527.1	30589.1	16184.2	25266.6	27568.7	14864.7	19867.7	22828.4	6134.5
1919	18875.1	28016.0	12892.4	46342.0	2540.8	3858.9	66272.6	38742.6	11244.4	29871.8	9328.4	11251.2	41228.9	2824.5
1920	86519.7	15916.6	13081.5	10166.5	1626.0	13077.9	13013.1	8780.2	52231.2	34691.9	33063.6	48899.1	8601.4	9565.4
1921	17737.3	9842.0	8401.8	7864.8	254.1	5134.6	5630.9	4189.2	9822.2	14821.3	13089.2	14414.8	13094.0	4489.5
1922	21847.3	13468.7	4982.0	6372.0	488.3	3308.7	7909.3	4280.0	13078.0	14060.1	9430.8	12134.4	6747.0	2682.1
1923	142592.3	122640.9	44149.4	57833.1	1673.5	21648.3	70029.0	22438.8	144981.2	121793.2	58669.7	73466.1	60083.0	18958.1
1924	18166.4	7234.7	1780.9	1298.1	274.8	800.3	3556.8	3061.7	11194.5	8280.7	3619.1	9525.5	1238.8	274.2
1925	7866.8	3706.3	1759.7	6366.6	1161.3	82.8	3618.6	6941.1	6752.4	4326.6	272.2	242.1	5441.1	175.2
1926	12573.9	82.3	478.8	181.3	692.1	0.2	193.9	3852.7	1360.1	4522.9	498.2	0.0	431.8	80.4
1927	21769.0	16237.7	8608.5	11963.0	1062.0	3425.2	14617.8	8812.7	20179.8	14267.0	6137.9	10981.7	25080.6	1616.3
1928	93873.8	36956.5	29877.9	49864.7	1270.6	9907.1	49521.6	30086.1	69782.1	67027.2	32674.8	27073.3	58741.2	9198.7
1929	46776.8	12119.2	9079.4	13481.1	725.9	4166.7	23036.3	7982.7	21197.0	28382.8	13951.1	15484.0	7423.7	2457.9
1930	86470.7	87930.1	28382.1	34793.3	629.0	13409.0	52960.6	20087.7	66076.1	66837.4	48628.3	47983.9	41955.1	14930.1
1931	7943.4	6981.6	5629.8	13968.1	931.6	1122.7	10738.6	13491.6	3572.9	9418.5	913.1	3256.0	22398.8	71.8
1932	28534.3	7910.0	8553.8	11810.4	334.9	1849.3	2682.8	5686.8	5641.1	15493.8	1773.8	3111.4	27728.4	63.8
1933	80308.1	18457.7	7499.2	8009.7	316.3	3444.1	9485.6	3454.6	41741.7	31240.4	14809.9	14270.7	4837.9	2929.1
1934	1409.3	0.0	0.0	80.1	36.2	0.0	0.0	186.8	0.0	0.0	0.0	0.0	280.8	0.0
1935	21748.2	3326.4	8782.9	10841.2	1477.1	302.8	8187.9	6286.2	7812.9	14846.1	1754.3	772.7	19958.2	22.4
1936	7734.1	0.0	304.9	955.3	156.7	0.0	0.0	6.8	421.5	1527.2	0.0	0.0	1137.1	0.0
1937	9732.1	4670.4	212.7	100.3	609.6	41.6	1974.5	1520.6	5727.7	3874.4	312.0	924.1	399.1	28.8
1938	19136.0	4258.4	8838.7	7330.6	1382.9	3098.4	4023.6	4222.7	10183.7	10182.2	9836.1	9267.6	18838.5	2449.3
1939	8193.2	0.0	2272.1	1137.6	528.0	912.9	87.3	178.7	1104.4	3447.3	2026.1	1436.8	3486.5	694.0
1940	4468.9	7.4	3710.1	4576.1	564.5	1267.0	1282.3	2333.4	535.5	3207.1	251.1	1263.4	12911.1	477.8
1941	121148.7	98881.6	34420.3	46256.9	2906.6	20862.6	61788.5	27443.1	128792.6	91849.7	59836.8	61668.5	48483.7	14547.8
1942	83467.6	33808.1	16742.5	26513.1	2781.1	7304.9	44137.0	22144.5	43350.0	53479.5	23737.2	23133.5	25330.6	6221.0
1943	2178.1	1124.3	18.1	309.1	472.8	86.7	1882.9	3622.2	338.4	87.2	374.4	8.4	570.1	816.7
1944	83108.3	73748.2	24356.8	39121.3	2983.2	14882.1	56866.8	24899.1	101707.4	52277.1	36280.4	58729.4	51582.8	9804.3
1945	28666.9	9436.5	7508.0	7368.5	1774.3	4925.3	4886.2	5875.1	15135.0	15981.5	17756.9	14977.8	10489.8	5753.0
1946	79490.9	70190.8	27222.5	35485.8	1810.1	12075.3	37742.5	25223.5	103801.3	66101.2	29850.7	56863.6	51486.0	4193.4
1947	39887.8	14434.9	8256.0	11626.1	656.5	2584.2	20223.0	10860.7	20344.4	16830.5	13606.0	7978.2	7503.1	4256.8
1948	38304.8	18134.2	14898.9	14980.7	705.4	6310.1	7415.8	2094.9	24725.3	30534.4	15736.5	18113.2	30236.1	4170.4
1949	126411.1	43210.3	27096.8	36386.0	2305.9	14730.2	47736.8	24772.7	74982.6	88114.5	47260.3	58221.9	28130.7	8497.1
1950	4727.7	1877.9	1821.1	8224.7	1648.5	138.2	12683.1	12779.2	3131.8	2261.3	92.0	844.9	10743.8	209.4
1951	85214.5	43783.0	31887.3	63068.1	3729.2	9867.9	81980.5	47863.9	58662.7	56243.7	23257.8	28276.5	85205.3	5456.1
1952	2108.5	813.0	197.9	845.4	832.9	19.2	4303.1	5200.4	503.9	187.2	66.3	30.9	2087.8	181.8
1953	3241.8	20778.2	2961.3	15206.8	1481.9	1265.0	34836.0	8746.1	10465.2	5033.4	970.1	7431.6	12723.7	66.0
1954	862.6	19.9	78.6	1786.2	702.8	8.9	2083.8	3191.3	8.8	43.1	66.6	33.1	3040.3	0.0
1955	1419.0	33.7	542.2	2790.5	381.4	6.2	1098.1	2091.5	33.5	381.6	152.3	66.3	8409.3	0.0
1956	1555.4	28.7	21.5	27.2	291.9	4.7	14.1	24.1	20.3	200.3	228.2	149.7	35.3	5.7
1957	46373.7	27568.8	31638.7	42274.3	1387.4	19069.9	41018.4	32761.8	53761.8	42180.8	48677.8	84819.8	89983.0	17448.8
1958	81157.8	21522.3	26218.8	26348.1	2231.0	14156.3	20971.6	10725.9	38362.1	57854.6	47536.3	32647.4	40400.1	18195.0
1959	7872.5	10617.7	4818.9	10861.6	1892.4	1817.2	14491.1	8108.0	10715.2	6826.2	1900.6	4982.2	19300.0	1271.8
1960	18827.2	18478.9	9847.7	19138.4	1706.2	5442.1	29082.9	18627.8	26276.2	13481.9	15915.4	17836.4	29884.0	5357.0
1961	187329.9	146989.7	21194.4	38248.1	2012.1	6318.0	25610.0	22580.3	10071.2	21694.4	10205.4	10828.2	72104.3	4348.7
1962	63892.6	36757.3	7803.8	14278.2	1897.5	8084.0	30838.4	20778.8	76572.6	23007.5	19832.0	31529.5	11199.1	4008.2
1963	18492.1	13347.0	2944.8	8618.1	1332.6	1280.9	17183.0	13664.6	13008.0	10737.8	4066.4	7696.7	5361.6	253.0
1964	2988.5	2816.2	196.1	404.3	839.1	80.9	2256.6	2212.6	2080.6	1106.0	1063.6	486.6	2187.3	12.8
1965	84941.2	118243.8	30840.1	59265.4	1891.1	14332.3	98128.6	49704.5	116357.9	74746.8	51138.6	58208.6	64485.9	13384.7
1966	17849.8	8408.9	1279.3	3607.9	314.5	284.3	11444.2	3440.4	6850.0	7413.4	3270.2	1441.4	1581.0	986.3
1967	7250.2	11183.5	2067.0	11010.1	1468.0	181.5	24662.9	12426.4	6664.1	4639.7	2223.1	987.6	14436.8	223.6
1968	7746.0	16782.8	2536.9	9178.2	1622.5	1196.4	16508.4	17447.9	14812.6	8156.5	3911.4	9501.4	7389.0	121.2
1969	22873.9	17781.7	9171.7	20847.1	1806.0	3441.7	33361.2	32306.8	23896.8	17433.1	8115.4	9861.5	27891.2	2383.4
1970	4561.7	3964.3	5016.3	8066.6	827.4	2001.0	6121.9	4682.4	6807.3	4533.6	3673.5	5381.2	22459.3	751.6
1971	23434.0	24575.2	4673.8	10686.3	1080.1	2185.0	29981.1	11578.7	39809.2	11967.8	8430.6	10251.7	14064.2	1428.8
1972	28014.1	18362.8	10578.0	19919.1	1898.8	3843.0	20871.9	9478.6	22971.0	20349.4	10066.0	12983.8	28078.2	1833.8
1973	89407.8	59668.2	24314.7	35851.2	4810.4	10873.0	48524.9	32398.1	86129.3	50165.7	25402.3	42296.8	58442.9	4434.2
1974	8627.0	4868.2	1236.1	1196.6	219.6	486.9	2978.5	213.3	8127.4	5402.4	3982.8	9800.3	757.3	98.0
1975	20491.1	36298.8	12745.9	19142.2	1192.6	6300.4	29083.3	9670.9	31793.1	24949.6	16400.7	28748.9	31432.0	1747.1
1976	2403.6	2390.7	1436.4	2718.4	240.9	408.4	3529.9	5713.8	756.6	3296.4	3981.2	3957.8	5773.8	112.7
1977	14581.7	30004.9	4846.0	9528.4	2317.8	3467.6	21266.0	9544.2	34239.6	13660.3	11081.9	23090.2	8009.7	923.3
1978	4422.1	1484.8	2040.1	3399.1	1315.1	778.5	3197.4	4493.0	1376.1	4996.7	5966.0	8654.4	4819.6	636.6
1979	62606.8	66369.4	19321.1	27214.9	1800.0	10858.2	40077.4	21400.5	71899.5	61724.6	37384.5	51852.9	28647.2	6229.8
1980	44434.0	13581.1	8786.0	7526.5	911.7	3186.9	8143.9	4016.3	12538.7	29639.8	19481.8	12739.7	7359.3	2891.7
1981	94743.2	43740.0	18670.3	18083.3	1878.8	10275.4	39186.8	16366.0	78924.1	63657.3	36341.3	48812.0	11786.5	8459.4
1982	81987.1	39766.2	11821.7	12378.4	1434.4	9028.5	19810.4	11283.8	66329.3	30839.7	29829.1	46201.9	18167.2	6187.1
1983	15630.2	36056.6	2310.1	6727.0	2024.9	845.1	23256.9	18103.1	20303.6	13438.2	10826.5	8213.0	4391.7	1192.3
1984	23623.4	42683.4	12171.8	19546.2	1901.8	4008.0	24140.8	9257.0	47776.0	25609.8	12788.4	24571.5	38966.2	761.1
1985	15809.2	37131.8	5139.1	9830.9	1788.8	4086.4	27273.3	8911.1	30715.4	18803.9	10000.8	28681.8	8196.2	3378.6
1986	9438.8	14071.4	6258.2	13783.2	2589.2	1707.0	15298.3	9041.6	9858.1	12992.3	9899.2	12882.3	21078.9	454.2
1987	22926.2	32831.9	8197.0	16083.3	2800.2	3673.8	32327.7	22471.2	30286.8	21036.6	18856.8	21032.8	25816.4	3304.3
1988	22424.0	16362.0	3383.1	3182.8	310.8	1808.0	6998.8	3420.2	24706.4	14075.0	9983.0	13247.5	2308.0	1182.1
1989	7706.8	3432.4	3795.9	3875.4	556.7	2911.6	3354.4	2986.9	8479.5	7346.0	6806.8	13633.2	6618.1	2562.4
1990	37571.1	16723.3	13678.8	15980.6	1016.2	4571.6	11088.1	13711.8	13846.3	36018.7	18180.1	19552.3	26503.6	1917.7
1991	81818.3	33788.5	8868.4	10063.0	773.6	4299.2	14018.4	6966.9	41433.9	38809.0	23201.4	23913.8	6633.8	3198.9
1992	29815.9	32899.5	19021.7	30198.4	2808.4	10036.1	46146.5	17023.1	45896.3	28453.0	29804.2	43071.9	38762.1	7146.0
1993	56458.2	87059.9	31896.7	53257.2	3804.4	16744.4	77237.7	56678.6	108778.9	59947.2	38257.1	75764.8	81040.2	8900.1
1994	11461.8	30149.9	4060.1	8868.8	803.6	6280.7	23070.2	249.8	29687.4	12038.4	18409.8	30014.3	4170.1	3863.0
1995	40186.2	16380.9	26083.6	20970.5	965.9	11012.2	21822.3	321.5	20455.7	41986.4	36044.2	31472.3	43636.0	10813.4
1996	89826.8	46199.1	17414.9	23839.9	2560.4	9417.8	53805.5	2966.5	36468.9	27873.8	25889.3	41910.8	50581.0	4986.9
1997	11136.8	11388.0	13871.5	18631.1	2437.3	5196.2	17863.1	230.9	11009.0	18434.7	13758.1	19525.4	46464.1	2577.8
1998	27837.9	8428.8	19338.7	15475.7	1427.9	9815.4	11161.2	196.9	12403.9	28430.4	33025.9	29356.9	44624.8	9454.8
1999	20962.8	26830.9	9878.8	10844.1	728.3	5362.3	18704.8	212.8	21910.0	17284.3	26577.8	20266.9	29873.8	8089.5
2000	7736.8	5846.9	6946.7	7264.7	295.4	1778.2	10433.5	201.0	4136.7	9841.8	8834.5	9404.1	18190.0	578.4

Appendix G Recharge from Precipitation (cubic feet per year)



APPENDIX H

RECHARGE FROM GROUNDWATER IRRIGATION

Appendix H Recharge from Ground Water Irrigation Colorado

Year	Cheyenne	KitCarson	Lincoln	Logan	Phillips	Sedgwick	Washington	Yuma
1918	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1919	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1920	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1921	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1922	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1923	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1924	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1925	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1926	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1927	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1928	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1929	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1930	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1931	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1932	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1933	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1934	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1935	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1936	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1937	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1938	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1939	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1940	37.9	0.0	0.0	58.2	234.6	0.0	73.2	0.0
1941	28.2	0.0	1.8	33.8	133.8	0.0	184.2	39.0
1942	30.6	0.0	2.1	40.5	289.1	0.0	178.2	49.5
1943	42.6	0.0	2.4	66.9	453.3	0.0	203.7	76.8
1944	46.6	0.0	2.1	60.3	407.7	0.0	285.9	66.7
1945	66.6	0.0	1.5	30.9	197.1	0.0	320.4	44.1
1946	143.4	0.0	2.1	82.8	361.0	0.0	434.7	100.8
1947	128.7	129.9	2.1	61.0	361.5	0.0	788.0	266.2
1948	90.3	480.0	122.4	84.9	466.9	0.0	1006.9	267.4
1949	96.6	864.6	136.6	46.3	462.0	56.8	728.4	524.1
1950	186.9	1252.7	160.6	53.4	812.3	70.8	973.0	586.4
1951	197.1	1080.0	123.9	35.7	449.7	117.9	957.9	1073.4
1952	243.6	1825.5	201.3	73.9	1203.3	236.8	1477.3	2436.8
1953	303.3	1946.3	163.3	98.6	1034.1	180.3	1508.7	2686.4
1954	318.3	3098.6	236.2	80.6	1217.7	180.2	1917.3	3604.8
1955	388.9	5029.9	197.4	87.6	1245.0	187.8	1491.2	4290.9
1956	498.6	13139.8	234.0	68.7	1636.5	309.9	2009.5	6571.6
1957	296.5	8652.4	137.4	134.4	1625.4	394.2	1718.0	6101.3
1958	213.0	9315.1	138.6	194.4	1364.7	270.0	1895.5	5635.5
1959	291.3	16296.8	245.4	136.9	1746.6	391.8	2131.6	7988.5
1960	338.4	14867.2	193.6	138.9	1913.7	394.5	2211.2	8638.7
1961	265.4	18007.5	177.2	111.3	1719.0	307.2	1759.9	6046.9
1962	348.6	16051.8	167.9	97.3	1577.1	283.0	1950.5	4872.6
1963	486.5	24735.1	206.8	179.3	2384.6	406.3	2295.2	8227.3
1964	606.0	33886.8	248.0	194.3	4760.5	472.9	2607.0	13089.4
1965	584.6	20188.8	120.9	109.5	4068.6	288.7	2475.4	11171.2
1966	720.7	39370.7	222.8	118.9	5746.5	271.7	3420.1	16704.9
1967	708.0	36221.6	174.9	101.2	5470.5	387.4	4278.2	31395.8
1968	934.1	45010.4	208.3	348.3	13176.5	866.8	5503.5	36426.6
1969	742.3	47361.8	226.0	336.0	13649.9	1225.3	5668.7	43168.4
1970	836.7	49646.9	254.8	375.9	17303.7	1330.2	5736.9	46061.5
1971	1320.6	62786.3	298.2	287.2	14471.6	1204.4	5615.1	50064.2
1972	1398.7	46253.1	240.9	328.7	14853.4	1273.9	6111.1	48098.9
1973	1734.3	62268.7	280.8	822.0	17083.6	2122.8	5467.5	42714.0
1974	2886.1	56709.1	364.8	1384.1	26186.5	6021.1	10576.0	72568.9
1975	2986.3	58606.7	474.9	1496.4	24863.4	6479.7	9808.4	72567.3
1976	3278.7	68566.0	540.8	1729.5	30105.6	7932.0	11616.7	78041.5
1977	3428.8	58062.3	461.0	1525.2	25780.2	6972.0	13890.0	74717.5
1978	3833.4	98386.8	818.0	1920.4	32711.8	8950.3	11597.2	91698.0
1979	3234.2	46261.0	383.5	1381.8	24372.1	6579.2	9680.3	76299.5
1980	3210.1	50831.0	463.7	1884.0	28005.0	7804.7	11671.6	88518.8
1981	3034.9	56033.4	468.7	1402.9	24168.7	6822.8	10844.7	73726.3
1982	2804.8	41382.9	348.6	1062.5	18321.5	5039.5	8803.7	56242.7
1983	2941.3	36021.8	367.3	1222.1	20747.6	5678.7	8656.2	58716.7
1984	2947.8	46314.3	471.4	1480.3	23742.6	6562.1	8457.7	73389.0
1985	2809.1	38485.2	347.8	1458.9	23338.1	5987.9	8591.6	68721.3
1986	2872.3	48188.3	437.8	1408.5	21966.2	5833.8	9756.1	68015.2
1987	2786.2	41782.8	401.0	1368.1	22047.9	5975.3	8713.0	68421.0
1988	2625.9	48098.2	444.7	1403.9	22946.1	6180.3	10264.5	72089.0
1989	2186.9	44368.0	446.8	1151.7	18362.6	5086.7	9458.8	66427.3
1990	2232.9	42374.7	402.7	1294.0	21296.5	5802.0	7830.4	54952.9
1991	2380.2	38624.9	398.9	1180.2	21109.4	5581.1	10332.6	43979.2
1992	2537.1	40346.2	453.4	1127.4	18583.5	5030.7	9216.4	50181.5
1993	2982.9	39987.4	402.7	866.3	14400.3	4008.5	8929.2	47843.2
1994	2614.2	43067.8	445.0	1562.0	26175.2	6878.1	13129.0	57536.6
1995	2805.8	38981.4	378.9	1189.3	19546.1	5279.9	8146.0	50325.8
1996	2568.5	40416.2	401.7	920.7	9791.4	2916.7	7807.8	43637.1
1997	2518.9	40409.8	417.9	1229.5	20067.1	5723.8	9425.5	52213.6
1998	2644.4	37812.9	374.2	1177.4	18744.1	5187.5	10936.3	59408.7
1999	2830.8	39434.8	373.6	1091.5	14612.7	4372.2	6971.1	50170.5
2000	3282.0	47795.5	542.7	1730.0	23479.7	7227.4	11756.9	64308.8

Appendix H Recharge from Ground Water Irrigation Kansas

Year	Cheyenne	Decatur	Gove	Graham	Jewell	Logan	Norton	Phillips	Rawlins	Sheridan	Sherman	Thomas	Trego	Wallace
1918	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1919	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1920	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1921	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1922	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1923	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1924	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1925	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1926	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1927	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1928	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1929	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1930	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1931	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1932	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1933	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1934	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1935	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1936	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1937	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1938	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1939	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1940	340.8	229.7	0.0	0.0	0.0	0.0	40.9	81.3	82.8	181.4	83.4	75.8	0.0	0.0
1941	370.2	115.1	0.0	0.0	0.0	0.0	27.3	38.7	35.1	93.0	83.4	72.9	0.0	0.0
1942	982.6	186.3	0.0	0.0	0.0	0.0	28.7	40.2	43.2	123.1	91.2	81.6	0.0	0.0
1943	989.0	211.2	0.0	0.0	0.0	0.0	37.6	48.9	47.7	144.0	98.3	86.8	0.0	0.0
1944	938.8	117.8	0.0	0.0	0.0	0.0	20.7	36.7	36.1	86.1	72.8	67.2	0.0	0.0
1945	1002.2	174.8	0.0	0.0	0.0	0.0	38.0	46.8	36.7	126.4	84.2	75.8	0.0	0.0
1946	1274.7	157.4	0.0	0.0	0.0	0.0	39.0	50.4	48.3	137.8	78.3	88.7	0.0	0.0
1947	1129.2	162.9	0.0	0.0	0.0	0.0	29.1	41.1	42.8	133.9	132.9	72.0	0.0	0.0
1948	979.3	169.9	0.0	0.0	0.0	0.0	30.3	46.8	37.5	109.8	136.8	159.9	0.0	0.0
1949	937.2	148.1	0.0	0.0	0.0	0.0	24.0	34.2	36.7	107.4	235.8	148.7	0.0	0.0
1950	1111.5	183.1	0.0	0.0	0.0	0.0	44.1	64.9	174.9	168.4	378.0	181.8	0.0	0.0
1951	866.6	109.0	0.0	0.0	0.0	0.0	20.7	57.8	92.7	98.4	239.1	175.5	0.0	0.0
1952	1388.3	256.6	0.0	0.0	0.0	0.0	81.0	116.4	213.8	237.5	1242.8	491.1	0.0	0.0
1953	1228.3	229.6	0.0	0.0	0.0	53.4	51.9	224.4	367.8	336.8	1367.2	388.1	0.0	0.0
1954	2208.4	336.8	0.0	117.9	0.0	87.8	319.2	844.9	433.1	443.0	1861.3	405.6	63.3	56.7
1955	2619.4	564.6	93.8	168.9	0.0	73.8	410.7	1163.9	677.0	1153.6	3171.6	933.6	66.1	59.1
1956	3660.6	917.6	274.8	249.0	209.7	80.4	524.3	1663.3	1021.7	2711.2	5680.3	2912.4	189.6	137.1
1957	3667.3	807.6	178.7	139.8	96.9	80.1	368.3	1161.1	877.9	2538.6	5172.8	2041.3	102.6	97.2
1958	4122.7	897.7	214.2	157.6	94.5	106.9	414.9	1278.7	896.4	2903.0	6164.0	2389.0	168.9	99.0
1959	5075.5	1271.6	353.3	238.2	124.5	136.8	624.2	1814.4	1233.0	4307.3	8878.3	3589.5	213.9	102.2
1960	6602.1	1406.6	312.9	247.9	93.9	120.9	614.1	1469.1	1369.6	4218.1	7868.3	3229.4	220.4	118.4
1961	5092.4	1646.6	189.7	196.0	123.8	184.7	640.0	1878.2	1074.0	3228.3	6965.5	3006.2	47.0	80.6
1962	3754.1	887.6	301.0	237.6	126.8	120.9	600.3	1034.4	697.7	3196.7	7129.2	2476.8	187.3	83.9
1963	7660.4	1789.1	499.4	268.8	126.8	256.5	614.7	1738.2	1322.0	4384.2	10972.3	3686.6	286.4	101.0
1964	10254.6	1844.5	867.9	344.4	114.8	733.7	864.0	2688.2	1616.9	7948.4	16884.5	6182.2	380.9	157.1
1965	7846.8	1092.6	380.4	296.7	114.5	488.3	801.8	1988.4	1204.8	3975.1	15296.3	4012.9	161.1	159.7
1966	10414.3	1665.6	1174.5	529.1	190.1	871.5	763.3	1714.8	1738.8	7384.1	18360.4	6961.2	287.7	296.7
1967	11462.1	1828.0	1944.7	421.9	122.3	1048.0	532.5	891.7	2017.0	8300.9	19806.5	9339.9	231.3	270.5
1968	12309.5	1614.7	1802.0	530.1	78.7	1091.9	360.3	727.3	2127.6	9078.3	24462.7	9155.2	234.0	430.2
1969	12556.0	2834.8	2161.4	440.8	86.2	2231.0	580.3	928.1	2202.4	12066.8	24902.7	9611.6	300.6	397.3
1970	14049.0	2882.4	2565.8	481.1	123.3	2773.1	786.4	1391.4	2468.9	15198.0	29780.7	10582.7	366.5	537.7
1971	14208.2	2808.0	3803.3	613.8	130.0	3150.9	1550.6	1963.4	2866.2	17883.2	31560.1	12467.2	475.0	544.2
1972	11173.0	2034.0	3641.1	648.8	104.2	2814.0	1988.2	2012.3	2026.2	18221.3	22068.7	12292.7	290.8	567.1
1973	13856.0	4048.4	3991.0	726.1	86.3	3008.8	3367.8	1838.7	4005.6	19818.4	29841.0	12378.1	331.4	724.5
1974	13719.2	3408.8	5470.9	870.1	163.4	2721.7	3061.1	3884.9	5263.6	24092.0	32061.2	15487.7	803.7	1167.9
1975	12662.4	2796.7	3708.1	887.1	77.0	2879.4	1414.9	1292.7	3197.5	16864.8	30715.1	12264.6	383.0	1146.0
1976	16030.8	4388.2	6861.5	1283.1	98.9	3854.3	2961.3	3034.8	3788.0	32389.8	42563.0	29808.2	479.2	1700.3
1977	12359.1	2480.0	3483.8	1054.9	230.9	2378.4	2268.8	1868.8	2388.5	21372.3	32225.7	18478.5	366.0	1343.1
1978	14608.4	3663.8	6492.2	1573.4	343.4	3388.9	2762.0	1714.7	3606.9	29670.1	38466.8	29048.5	342.5	1332.8
1979	9883.6	1744.5	2788.2	974.8	424.4	2040.7	1837.2	1208.4	2831.8	18247.1	25022.9	16384.5	323.8	966.4
1980	8700.8	3660.4	3384.5	984.4	374.9	2683.0	4028.8	2838.0	2401.2	28811.9	24084.2	27232.0	293.1	853.9
1981	10261.8	3617.4	3780.4	989.4	229.3	2978.2	1868.3	1340.8	2256.3	21342.5	34255.0	23057.8	387.5	1403.3
1982	8581.4	3207.2	4089.2	1066.8	174.6	2114.3	2203.4	1927.8	2847.9	18186.2	20838.5	14495.8	415.8	646.4
1983	9530.8	3835.1	4061.8	1012.6	206.1	3094.4	1961.4	1474.2	3059.8	18789.1	25781.8	16225.9	444.2	667.8
1984	8322.7	3983.9	4372.6	1246.8	311.2	2562.2	3630.1	1903.9	3008.3	26772.9	24238.0	19874.1	434.2	757.6
1985	8036.5	3868.1	4098.7	1627.4	226.8	2131.0	3198.5	1929.2	2568.8	21801.4	21638.4	19196.8	400.9	774.9
1986	10250.9	3287.8	4981.0	1383.4	273.1	2438.0	2830.2	1916.8	3093.0	21380.9	26231.0	26414.1	258.2	880.0
1987	10278.7	2143.7	3674.7	902.3	249.0	1542.4	2309.7	1782.3	3141.3	17039.2	21598.7	19785.5	320.0	720.9
1988	10629.1	1834.0	3634.8	907.0	304.9	2246.9	2586.1	1363.1	3804.3	20872.2	22408.1	20620.1	430.2	667.0
1989	11323.7	3581.8	3850.8	1053.2	227.3	2273.7	2968.8	2048.1	3838.2	23470.4	26848.5	24273.0	455.8	868.8
1990	11273.6	3038.6	3240.5	1209.1	287.0	2179.0	2965.7	1880.0	3870.2	19013.9	26997.0	22008.0	466.4	751.5
1991	9869.4	2870.7	3354.3	1444.2	334.8	1842.8	2542.2	1680.8	3270.9	18481.9	23052.3	19052.4	427.9	636.2
1992	8802.0	804.8	1282.0	643.1	72.2	1079.8	1137.8	682.6	1498.0	8645.1	14729.8	8648.0	137.5	536.0
1993	6780.4	758.7	957.1	501.1	29.0	895.7	940.2	683.3	1686.0	5879.1	13864.2	7799.2	80.9	473.5
1994	7964.2	1608.0	2586.1	936.4	249.3	923.4	1548.4	1219.0	2274.2	11407.0	18863.7	11872.5	310.2	621.2
1995	8834.6	2313.8	2401.2	1056.2	299.0	887.4	1861.5	1377.8	2280.9	11845.9	13388.3	10812.9	217.6	466.5
1996	8991.4	1631.0	1758.9	860.7	288.1	799.9	1089.2	722.0	1726.7	9398.2	14863.2	9804.1	183.9	511.4
1997	7088.6	2094.0	1636.3	861.2	253.1	861.7	1671.0	1277.7	2284.2	8077.6	14507.5	10032.8	233.4	378.8
1998	5613.1	1868.8	1802.0	730.9	203.4	886.0	1486.6	1084.0	2006.7	7283.5	12231.0	8170.9	224.4	387.9
1999	8634.6	1302.1	1389.5	567.7	246.4	845.3	1256.8	1163.8	1870.1	6385.0	10584.6	8640.4	227.1	384.4
2000	7308.7	2617.3	2051.1	926.8	314.8	833.6	1968.2	962.7	2984.0	10043.8	14524.0	11186.8	314.2	662.6

H2

Appendix H Recharge from Ground Water Irrigation Maricopa

Year	Arizona	Buffalo	Chilson	Clay	Dawson	Deval	Dusty	Enterprise	Fredonia	Fulton	Gaspar	Harlan	Hayes	Hutchinson	Kearney	Kelly	Lincoln	Nicholls	Perkins	Phelps	Smithfield	Webster
1918	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1919	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1920	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1921	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1922	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1923	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1924	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1925	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1926	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1927	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1928	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1929	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1930	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1931	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1932	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1933	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1934	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1935	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1936	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1937	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1938	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1939	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1940	48.1	169.2	249.2	0.8	1639.8	453.6	192.8	233.8	53.7	288.5	451.7	120.3	131.1	696.0	1539.3	349.1	1798.8	32.4	94.1	1799.7	488.3	525.0
1941	34.7	93.5	348.7	10.6	1394.8	322.8	147.5	134.7	69.7	165.5	398.9	134.4	95.8	913.8	1493.7	818.2	1632.1	34.2	78.8	1818.1	388.6	69.8
1942	28.3	76.9	281.8	16.3	1456.8	299.6	130.2	149.3	64.4	138.6	382.1	132.7	103.9	764.9	1689.6	1187.2	1662.7	34.6	69.5	1823.2	528.4	47.4
1943	28.0	104.2	320.8	21.3	2009.6	418.2	201.1	172.8	74.8	224.4	391.5	163.5	119.8	893.6	1449.8	1278.3	2399.4	35.6	126.7	1761.6	453.3	69.5
1944	35.6	132.3	511.5	21.3	1388.6	327.7	243.1	264.8	41.4	153.6	653.8	252.5	99.8	849.1	1733.3	1181.1	1848.8	33.6	107.8	1772.7	534.3	63.5
1945	28.6	108.3	316.0	21.3	2852.8	651.6	420.6	226.1	69.8	276.6	579.8	244.8	121.8	753.9	2849.6	2216.3	3573.3	27.6	133.6	1785.3	908.5	63.0
1946	22.8	169.8	662.7	16.8	2859.3	613.8	338.8	292.3	69.6	361.7	699.8	338.4	160.2	773.8	2384.1	2322.5	3125.6	30.1	97.8	1828.6	898.8	67.8
1947	138.4	8.8	717.3	8.1	59.0	669.4	468.3	347.4	67.8	418.6	14.4	696.6	176.2	1888.7	49.8	3242.6	3161.6	175.1	128.3	68.6	894.8	162.1
1948	138.4	9.6	786.7	8.1	21.9	912.6	597.3	388.2	126.8	422.4	11.6	696.8	118.4	1889.8	33.2	3731.7	107.5	143.7	243.4	49.9	764.6	169.4
1949	237.2	1.6	691.6	0.4	10.5	864.3	668.3	464.9	161.5	464.9	10.2	696.3	272.5	2182.6	76.8	4011.6	474.1	320.1	284.3	42.9	728.3	181.2
1950	269.2	2.4	773.7	0.6	20.6	936.3	80.3	62.8	171.5	24.1	8.3	62.8	65.2	324.8	77.9	3402.1	666.6	71.1	118.3	14.2	148.1	46.1
1951	108.7	1.1	728.2	0.3	25.8	271.1	20.9	35.2	27.2	10.2	3.7	44.8	49.8	469.8	38.4	2709.7	169.1	8.6	452.2	7.2	84.3	88.7
1952	334.4	4.3	1418.4	1.2	75.6	708.6	139.7	168.5	32.6	49.6	14.4	99.0	170.7	788.7	164.1	4884.8	1560.0	89.9	841.1	98.2	353.6	135.3
1953	676.1	18.6	1630.2	5.7	82.6	627.6	210.3	283.1	40.3	78.2	28.1	201.2	247.1	972.6	771.8	4116.2	3483.2	59.7	698.4	232.3	519.6	289.4
1954	768.5	32.3	2388.6	11.6	246.5	901.4	634.7	886.7	286.6	259.9	145.4	766.7	428.9	1494.3	1164.1	6516.6	5744.4	57.6	1118.7	288.6	1648.2	648.1
1955	651.8	37.2	2468.7	357.2	209.6	837.6	2171.1	149.8	679.7	776.3	884.2	1042.3	467.8	2357.4	709.7	8574.6	7262.6	89.1	1129.6	461.6	2755.6	2164.8
1956	1125.4	27.6	7482.1	148.9	1188.3	687.9	2752.3	1494.6	934.8	1288.6	691.7	2242.3	849.3	3663.9	3443.3	2997.6	10885.1	1677.1	6886.6	3439.3	694.1	3914.1
1957	1107.7	168.3	4312.8	213.0	2882.1	847.2	2546.1	2382.8	839.2	2348.6	1418.4	2832.8	977.5	3736.5	7282.6	9886.3	9344.3	1482.2	7811.6	1536.1	1446.2	4887.8
1958	717.6	117.6	3884.4	121.0	1801.8	701.8	2189.3	1893.5	1609.5	1574.9	952.8	1628.8	681.6	2716.4	8164.6	4284.4	8231.7	548.7	5868.6	5889.3	4888.2	825.4
1959	2329.7	548.5	7818.8	462.1	4283.1	1442.9	6442.1	3197.2	2382.7	4912.8	1889.4	4418.7	1080.6	6886.3	10478.7	8731.4	15166.0	1707.8	12853.4	10150.8	2788.6	2726.3
1960	2203.8	559.4	7438.4	462.2	4648.1	1668.2	6832.6	3128.1	3063.8	3922.6	2016.8	5302.8	1768.3	4375.1	10113.7	9428.8	16139.4	1897.0	16857.7	8737.4	2378.8	2855.1
1961	2082.8	283.1	2878.5	525.1	3788.7	763.8	3638.3	3168.6	1329.7	2018.6	1052.7	3183.9	1080.6	3975.7	10486.6	4837.3	4889.8	2165.1	775.6	8705.8	1638.4	3430.1
1962	1444.4	141.8	2615.1	203.0	1888.8	844.2	2191.4	2116.8	716.5	1288.7	760.3	1818.9	752.6	1784.7	6882.6	3884.4	2179.4	1134.5	958.9	6234.1	821.8	1852.7
1963	2844.7	457.6	4888.9	484.8	6328.9	1007.2	5228.9	4332.6	1817.1	3484.1	2868.2	4166.4	2116.2	4349.4	14488.1	6788.8	6873.4	2184.8	1152.6	13382.8	2858.4	3533.4
1964	4018.8	393.4	6488.8	688.4	5298.3	1683.8	6986.4	6845.6	2788.8	3783.3	2278.8	4288.1	2388.1	5817.4	12888.4	7232.4	8841.8	3357.8	1155.6	12231.6	2709.5	5688.2
1965	3528.8	454.8	6542.8	648.8	3488.8	788.2	4228.2	5848.3	2788.8	3487.3	1685.3	3882.1	2014.1	4982.3	13882.5	5733.3	4987.7	2383.2	967.8	12188.2	2462.8	3849.9
1966	4681.6	488.7	6388.8	747.8	5448.8	878.6	4181.8	5733.3	3388.8	3814.4	2488.3	3188.8	1871.2	5888.2	13888.8	6187.1	6812.1	3888.3	1488.8	11838.4	2888.1	5283.8
1967	5815.8	344.8	8487.3	841.1	4888.8	1721.6	5188.2	5888.8	4838.8	5888.8	2848.8	5878.2	2778.8	6842.8	17888.8	11488.8	8188.4	4288.8	2188.8	11828.4	4888.2	6847.3
1968	6488.2	852.1	1727.8	831.8	5338.4	1887.7	6188.7	6848.8	4838.8	6775.8	3888.1	6413.2	3888.8	8888.2	18477.8	13877.8	8284.8	4278.7	2788.1	12288.3	5838.3	7867.4
1969	7853.3	848.5	2588.2	1481.6	6821.1	1754.3	7188.8	6838.4	5488.2	8824.8	4838.2	7287.8	4888.1	10241.8	21488.8	13187.7	10888.5	4787.8	4848.2	21842.2	6128.6	8848.1
1970	8318.3	488.7	2388.8	1488.8	8143.5	1828.8	7488.8	8488.2	5488.8	7488.8	4888.2	8128.8	4888.2	11488.8	21888.8	14888.8	11888.2	5788.8	4888.5	28418.7	10488.8	8288.8
1971	8252.2	873.1	2888.4	1888.8	7218.8	1788.2	8288.4	8488.2	5888.2	8148.4	4918.1	8148.8	4888.8	11888.3	22888.8	15888.3	12888.8	5488.7	4888.8	30113.2	8758.5	8338.8
1972	8888.8	711.8	3887.3	1888.8	8148.8	2188.1	8888.8	8888.8	5888.8	8888.4	4888.8	8888.8	4888.8	11888.8	23888.8	15888.8	12888.8	5888.8	4888.8	30888.8	8888.8	8888.8
1973	8888.8	711.8	3887.3	1888.8	8148.8	2188.1	8888.8	8888.8	5888.8	8888.4	4888.8	8888.8	4888.8	11888.8	23888.8	15888.8	12888.8	5888.8	4888.8	30888.8	8888.8	8888.8
1974	8888.8	711.8	3887.3	1888.8	8148.8	2188.1	8888.8	8888.8	5888.8	8888.4	4888.8	8888.8	4888.8	11888.8	23888.8	15888.8	12888.8	5888.8	4888.8	30888.8	8888.8	8888.8
1975	10789.3	828.3	4278.8	1278.0	10725.8	1882.8	8917.8	12375.8	8488.4	11488.1	5888.8	10188.8	5888.8	14142.8	24748.4	17281.8	20837.7	8788.4	8888.8	41888.8	14888.4	8888.8
1976	10788.8	788.8	4888.8	1888.8	12187.7	2888.8	8888.8	12888.8	8888.8	12888.8	5888.8	10888.8	5888.8	14888.8	24888.8	17888.8	20888.8	8888.8	8888.8	41888.8	14888.4	8888.8
1977	5487.7	378.8	4788.8	888.8	6887.8	1431.8	3827.7	12788.8	1888.2	11388.8	1888.8	10888.8	1888.8	10888.8	24888.8	14888.8	20888.8	8888.8	8888.8	41888.8	14888.4	8888.8
1978	7884.8	841.8	8888.8	848.8	10787.8	2648.8	3488.7	12888.8	2888.8	12888.8	1888.8	10888.8	1888.8	10888.8	24888.8	14888.8	20888.8	8888.8	8888.8	41888.8	14888.4	8888.8
1979	5788.8	488.8	4888.8	888.8	6887.8	1488.8	3888.8	12888.8	1888.8	11888.8	1888.8	10888.8	1888.8	10888.8	24888.8	14888.8	20888.8	8888.8	8888.8	41888.8	14888.4	8888.8
1980	7888.8	787.8	8888.8	888.8	10788.8	2888.8	3888.8	12888.8	2888.8	12888.8	1888.8	10888.8	1888.8	10888.8	24888.8	14888.8	20888.8	8888.8	8888.8	41888.8	14888.4	8888.8
1981	5888.2	488.8	4888.8	888.8	7288.3	1888.8	3888.8	12888.8	1888.8	11888.8	1888.8	10888.8	1888.8	10888.8	24888.8	14888.8	20888.8	8888.8	8888.8	41888.8	14888.4	8888.8
1982	7888.8	787.8	8888.8	888.8	10788.8	2888.8	3888.8	12888.8	2888.8	12888.8	1888.8	10888.8	1888.8	10888.8	24888.8	14888.8	20888.8	8888.8	8888.8	41888.8	14888.4	8888.8
1983	5888.8	488.8	4888.8	888.8	7288.8	1888.8	3888.8	12888.8	1888.8	11888.8	1888.8	10888.8	1888.8	10888.8	24888.8	14888.8	20888.8	8888.8	8888.8	41888.8	14888.4	8888.8
1984	7888.8	787.8	8888.8	888.8	10788.8	2888.8	3888.8	12888.8	2888.8	12888.8	1888.8	10888.8	1888.8	10888.8	24888.8	14888.8	20888.8	8888.8	8888.8	41888.8	14888.4	8888.8
1985	5888.8	488.8	4888.8	888.8	7288.8	1888.8	3888.8	12888.8	1888.8	11888.8	1888.8	10888.8	1888.8	10888.8	24888.8	14888.8	20888.8	8888.8	8888.8	41888.8	14888.4	8888.8
1986	7888.8	787.8	8888.8	888.8	10788.8	2888.8	3888.8	12888.8	2888.8	12888.8	1888.8	10888.8	1888.8	10888.8	24888.8	14888.8	20888.8	8888.8	8888.8	41888.8	14888.4	8888.8
1987	6053.2	511.4	3848.8	888.4	8892.8	1838.4	2988.7	13078.3	1488.8	8747.1	918.8	10888.8	848.8	9783.2	33881.3	10888.1	20321.2	6388.1	7888.8	37212.3	11188.8	8888.8
1988	8782.4	670.5	4883.1	1145.2	11311.1	1888.4	3473.2	15881.5	1488.8	10888.3	1888.2	14888.1	1888.2	10888.2	42778.1	18488.2	28728.8	8888.1	7888.8	47888.8	14888.4	8888.8
1989	8841.8	638.8	4888.8	788.8	8888.8	1888.7	3888.8	15888.8	1888.8	10888.8	1888.8	15888.8	1888.8	10888.8	42888.8	18888.8	28888.8	8888.8	7888.8	47888.8	14888.4	8888.8
1990	8888.8	787.8	8888.8	888.8	8888.8	1888.8	3888.8	15888.8	1888.8	10888.8	1888.8	15888.8	1888.8	10888.8	42888.8	18888.8	28888.8	8888.8	7888.8	47888.8	14888.4	8888.8
1991	8888.8	787.8	8888.8	888.8	8888.8	1888.8	3888.8	15888.8	1888.8	10888.8	1888.8	15888.8	1888.8	10888.8	42888.8	18888.8	28888.8	8888.8	7888.8	47888.8	14888.4	8888.8
1992	8888.8	787.8	8888.8	888.8	8888.8	1888.8	3888.8	15888.8	1888.8	10888.8	1888.8	15888.8	1888.8	10888.8	42888.8	18888.8	28888.8	8888.8	7888.8	47888.8	14888.4	8888.8
1993	8888.8	787.8	8888.8	888.8	8888.8	1888.8	3888.8	15888.8	1888.8	10888.8	1888.8	15888.8	1888.8	10888.8	42888.8	18888.8	28888.8	8888.8	7888.8	47888.8	14888.4	8888.8
1994	8888.8	787.8	8888.8	888.8	8888.8	1888.8	3888.8	15888.8	1888.8	10888.8	1888.8	15888.8	1888.8	10888.8	42888.8	18888.8	28888.8	8888.8	7888.8	47888.8	14888.4	8888.8
1995	8888.8	787.8	8888.8	888.8	8888.8	1888.8	3888.8	15888.8	1888.8	10888.8	1888.8	15888.8	1888.8	10888.8	42888.8	18888.8	28888.8	8888.8	7888.8	47888.8	14888.4	8888.8
1996	8888.8	787.8	8888.8	888.8	8888.8	1888.8	3888.8	15888.8	1888.8	10888.8	1888.8	15888.8	1888.8	10888.8	42888.8	18888.8	28888.8	8888.8	7888.8	47888.8	14888.4	8888.8
1997	8888.8	787.8	8888.8	888.8	8888.8	1888.8	3888.8	15888.8	1888.8	10888.8	1888.8	15888.8	1888.8	10888.8	42888.8	18888.8	28888.8	8888.8	7888.8	47888.8	14888.4	8888.8
1998	8888.8	787.8	8888.8	888.8	8888.8	1888.8	3888.8	15888.8	1888.8	10888.8	1888.8	15888.8	1888.8	10888.8	42888.8	18888.8	28888.8	8888.8	7888.8	47888.8	14888.4	8888.8
1999	8888.8	787.8	8888.8	888.8	8888.8	1888.8	3888.8	15888.8	1888.8	10888.8	1888.8	15888.8	1888.8	10888.8	42888.8	18888.8	28888.8	8888.8	7888.8	47888.8	14888.4	8888.8
2000	8888.8	787.8	8888.8	888.8	8888.8	1888.8	3888.8	15888.8	1888.8	10888.8	1888.8	15888.8	1888.8	10888.8	42888.8	18888.8	28888.8	8888.8	7888.8	47888.8	14888.4	8888.8

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APPENDIX I

RECHARGE FROM CANALS AND LATERALS

Appendix I Recharge from Canals and Laterals Colorado

Year	Cheyenne	KitCarson	Lincoln	Logan	Phillips	Sedgwick	Washington	Yuma
1918	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1919	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1920	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1921	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1922	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1923	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1924	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1925	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1926	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1927	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1928	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1929	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1930	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1931	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1932	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1933	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1934	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1935	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1936	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1937	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1938	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1939	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1940	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1941	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1942	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1943	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1944	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1945	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1946	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1947	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1948	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1949	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1950	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1951	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1952	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1953	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1954	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1955	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1956	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1957	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1958	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1959	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1960	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1961	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1962	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1963	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1964	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1965	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1966	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1967	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1968	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1969	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1970	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1971	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1972	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1973	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1974	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1975	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1976	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1977	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1978	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1979	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1980	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1981	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1982	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1983	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1984	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1985	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1986	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1987	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1988	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1989	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1990	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1991	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1992	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1993	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1994	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1995	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1996	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1997	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1998	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1999	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Appendix I Recharge from Canals and Laterals Kansas

Year	Cheyenne	Decatur	Gove	Graham	Jewell	Logan	Norton	Phillips	Rawlins	Sheridan	Sherman	Thomas	Trego	Wallace
1918	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1919	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1920	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1921	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1922	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1923	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1924	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1925	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1926	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1927	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1928	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1929	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1930	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1931	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1932	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1933	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1934	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1935	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1936	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1937	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1938	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1939	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1940	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1941	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1942	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1943	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1944	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1945	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1946	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1947	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1948	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1949	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1950	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1951	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1952	0.0	0.0	0.0	0.0	163.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1953	0.0	0.0	0.0	0.0	268.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1954	0.0	0.0	0.0	0.0	1047.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1955	0.0	0.0	0.0	0.0	2500.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1956	0.0	0.0	0.0	0.0	3332.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1957	0.0	0.0	0.0	0.0	2083.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1958	0.0	0.0	0.0	0.0	2363.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1959	0.0	0.0	0.0	0.0	2524.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1960	0.0	0.0	0.0	0.0	2274.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1961	0.0	0.0	0.0	0.0	2416.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1962	0.0	0.0	0.0	0.0	2555.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1963	0.0	0.0	0.0	0.0	3386.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1964	0.0	0.0	0.0	0.0	1866.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1965	0.0	0.0	0.0	0.0	2842.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1966	0.0	0.0	0.0	0.0	3273.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1967	0.0	0.0	0.0	0.0	2736.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1968	0.0	0.0	0.0	0.0	2651.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1969	0.0	0.0	0.0	0.0	3218.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1970	0.0	0.0	0.0	0.0	2680.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1971	0.0	0.0	0.0	0.0	2418.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1972	0.0	0.0	0.0	0.0	2197.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1973	0.0	0.0	0.0	0.0	2624.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1974	0.0	0.0	0.0	0.0	2386.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1976	0.0	0.0	0.0	0.0	2888.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1976	0.0	0.0	0.0	0.0	3254.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1977	0.0	0.0	0.0	0.0	2148.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1978	0.0	0.0	0.0	0.0	3081.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1979	0.0	0.0	0.0	0.0	2853.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1980	0.0	0.0	0.0	0.0	2786.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1981	0.0	0.0	0.0	0.0	2628.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1982	0.0	0.0	0.0	0.0	3810.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1983	0.0	0.0	0.0	0.0	2711.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1984	0.0	0.0	0.0	0.0	3342.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1985	0.0	0.0	0.0	0.0	3204.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1986	0.0	0.0	0.0	0.0	3871.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1987	0.0	0.0	0.0	0.0	2833.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1988	0.0	0.0	0.0	0.0	3816.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1989	0.0	0.0	0.0	0.0	2810.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1990	0.0	0.0	0.0	0.0	2886.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1991	0.0	0.0	0.0	0.0	2953.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1992	0.0	0.0	0.0	0.0	1781.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1993	0.0	0.0	0.0	0.0	2878.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1994	0.0	0.0	0.0	0.0	4710.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1995	0.0	0.0	0.0	0.0	4479.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1996	0.0	0.0	0.0	0.0	2798.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1997	0.0	0.0	0.0	0.0	3488.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1998	0.0	0.0	0.0	0.0	3382.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1999	0.0	0.0	0.0	0.0	3870.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2000	0.0	0.0	0.0	0.0	3620.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Appendix I Rainfall from Canada and Iceland Publication

Year	Adams	Buffalo	Chase	Clay	Dawson	Elliott	Gandy	Franklin	Franklin	Fuentes	Grogan	Harlan	Hayes	Hitchcock	Kimball	Knox	Lincoln	Mcdonald	Perkins	Phelps	Red Willow	Webster
1910	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1911	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1912	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1913	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1914	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1915	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1916	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1917	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1918	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1919	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1920	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1921	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1922	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1923	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1924	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1925	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1926	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1927	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1928	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1929	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1930	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1931	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1932	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1933	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1934	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1935	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1936	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1937	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1938	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1939	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1940	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1941	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1942	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1943	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1944	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1945	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1946	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1947	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1948	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1949	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1950	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1951	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1952	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1953	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1954	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1955	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1956	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1957	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1958	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1959	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1960	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1961	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1962	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1963	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1964	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1965	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1966	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1967	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1968	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1969	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1970	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1971	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1972	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1973	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1974	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1975	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1976	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1977	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1978	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1979	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1980	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1981	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1982	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1983	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1984	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1985	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1986	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1987	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1988	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1989	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1990	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1991	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1992	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1993	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1994	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1995	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1996	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1997	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1998	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1999	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

APPENDIX J
RECHARGE FROM SURFACE WATER IRRIGATION

Appendix J — Recharge from Surface Water Irrigation — Colorado

Year	Cheyenne	McClenan	Lincoln	Logan	Phillips	Sedgwick	Washington	Yuma
1918	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1919	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1920	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1921	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1922	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1923	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1924	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1925	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1926	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1927	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1928	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1929	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1930	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1931	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1932	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1933	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1934	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1935	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1936	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1937	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1938	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1939	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1940	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2787.0
1941	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2864.0
1942	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2602.0
1943	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3186.2
1944	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3225.8
1945	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3246.4
1946	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3497.4
1947	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3084.8
1948	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1920.8
1949	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1783.6
1950	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2338.2
1951	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2353.6
1952	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2809.0
1953	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3298.4
1954	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4387.6
1955	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4119.4
1956	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4186.4
1957	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2874.0
1958	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3021.8
1959	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3775.6
1960	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3599.2
1961	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3181.0
1962	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2560.8
1963	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3336.2
1964	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3320.8
1965	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2300.0
1966	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2019.6
1967	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2548.8
1968	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3418.4
1969	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3248.2
1970	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2007.2
1971	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2123.2
1972	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2011.4
1973	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1278.2
1974	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2843.8
1975	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2832.6
1976	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3144.8
1977	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2488.6
1978	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2811.6
1979	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2508.0
1980	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1898.8
1981	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1479.4
1982	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2429.8
1983	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2340.0
1984	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2286.6
1985	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1283.0
1986	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2882.6
1987	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2195.4
1988	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2878.4
1989	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2089.0
1990	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2138.4
1991	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1637.8
1992	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2882.2
1993	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2393.4
1994	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1318.0
1995	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1783.0
1996	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1106.0
1997	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1909.8
1998	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2879.4
1999	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2448.8
2000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3020.0

Appendix J Recharge from Surface Water Irrigation Kansas

Year	Cheyenne	Decatur	Gove	Graham	Jewell	Logan	Norton	Phillips	Rawlins	Sheridan	Sherman	Thomas	Trego	Wallace
1918	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1919	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1920	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1921	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1922	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1923	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1924	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1925	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1926	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1927	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1928	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1929	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1930	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1931	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1932	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1933	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1934	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1935	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1936	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1937	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1938	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1939	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1940	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1941	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1942	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1943	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1944	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1945	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1946	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1947	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1948	0.0	0.0	0.0	0.0	5.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1949	0.0	0.0	0.0	0.0	5.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1950	0.0	0.0	0.0	0.0	4.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1951	0.0	0.0	0.0	0.0	4.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1952	0.0	0.0	0.0	0.0	46.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1953	0.0	0.0	0.0	0.0	164.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1954	0.0	0.0	0.0	0.0	98.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1955	0.0	0.0	0.0	0.0	278.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1956	0.0	0.0	0.0	0.0	241.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1957	0.0	0.0	0.0	0.0	208.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1958	1.1	0.0	0.0	0.0	100.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1959	1.5	0.0	0.0	0.0	288.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1960	1.5	0.0	0.0	0.0	178.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1961	1.3	0.0	0.0	0.0	182.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1962	0.8	0.0	0.0	0.0	136.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1963	0.9	0.0	0.0	0.0	167.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1964	1.1	0.0	0.0	0.0	226.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1965	0.9	0.0	0.0	0.0	171.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1966	0.6	0.0	0.0	0.0	304.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1967	0.9	0.0	0.0	0.0	210.8	0.0	1068.8	1574.7	0.0	0.0	0.0	0.0	0.0	0.0
1968	0.8	0.0	0.0	0.0	244.4	0.0	1738.2	2511.0	0.0	0.0	0.0	0.0	0.0	0.0
1969	0.9	0.0	0.0	0.0	136.6	0.0	1333.7	1929.2	0.0	0.0	0.0	0.0	0.0	0.0
1970	0.8	0.0	0.0	0.0	272.8	0.0	1400.2	2028.6	0.0	0.0	0.0	0.0	0.0	0.0
1971	0.8	0.0	0.0	0.0	280.0	0.0	1036.3	1497.8	0.0	0.0	0.0	0.0	0.0	0.0
1972	0.6	0.0	0.0	0.0	172.8	0.0	843.8	788.7	0.0	0.0	0.0	0.0	0.0	0.0
1973	0.6	0.0	0.0	0.0	168.1	0.0	1196.3	1729.1	0.0	0.0	0.0	0.0	0.0	0.0
1974	0.8	0.0	0.0	0.0	250.8	0.0	677.7	980.3	0.0	0.0	0.0	0.0	0.0	0.0
1975	0.9	0.0	0.0	0.0	216.9	0.0	1087.2	1887.1	0.0	0.0	0.0	0.0	0.0	0.0
1976	0.9	0.0	0.0	0.0	313.9	0.0	914.2	1328.4	0.0	0.0	0.0	0.0	0.0	0.0
1977	0.9	0.0	0.0	0.0	171.8	0.0	684.2	989.8	0.0	0.0	0.0	0.0	0.0	0.0
1978	0.6	0.0	0.0	0.0	174.0	0.0	777.1	1124.2	0.0	0.0	0.0	0.0	0.0	0.0
1979	0.9	0.0	0.0	0.0	104.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1980	0.9	0.0	0.0	0.0	263.9	0.0	260.9	377.3	0.0	0.0	0.0	0.0	0.0	0.0
1981	0.8	0.0	0.0	0.0	99.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1982	0.6	0.0	0.0	0.0	138.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1983	0.4	0.0	0.0	0.0	178.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1984	0.6	0.0	0.0	0.0	178.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1985	0.6	0.0	0.0	0.0	123.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1986	0.8	0.0	0.0	0.0	148.8	0.0	412.1	595.1	0.0	0.0	0.0	0.0	0.0	0.0
1987	0.6	0.0	0.0	0.0	167.1	0.0	474.8	685.8	0.0	0.0	0.0	0.0	0.0	0.0
1988	0.8	0.0	0.0	0.0	213.1	0.0	346.6	676.8	0.0	0.0	0.0	0.0	0.0	0.0
1989	0.8	0.0	0.0	0.0	167.0	0.0	262.1	384.7	0.0	0.0	0.0	0.0	0.0	0.0
1990	0.6	0.0	0.0	0.0	188.9	0.0	296.3	433.9	0.0	0.0	0.0	0.0	0.0	0.0
1991	0.6	0.0	0.0	0.0	134.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1992	0.6	0.0	0.0	0.0	88.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1993	0.8	0.0	0.0	0.0	13.0	0.0	308.7	448.6	0.0	0.0	0.0	0.0	0.0	0.0
1994	0.6	0.0	0.0	0.0	138.7	0.0	843.2	786.7	0.0	0.0	0.0	0.0	0.0	0.0
1995	0.4	0.0	0.0	0.0	137.7	0.0	1064.9	1547.7	0.0	0.0	0.0	0.0	0.0	0.0
1996	0.6	0.0	0.0	0.0	117.2	0.0	966.8	1480.2	0.0	0.0	0.0	0.0	0.0	0.0
1997	0.6	0.0	0.0	0.0	96.8	0.0	1438.8	2092.4	0.0	0.0	0.0	0.0	0.0	0.0
1998	0.8	0.0	0.0	0.0	130.4	0.0	628.3	897.2	0.0	0.0	0.0	0.0	0.0	0.0
1999	0.8	0.0	0.0	0.0	136.6	0.0	587.8	821.1	0.0	0.0	0.0	0.0	0.0	0.0
2000	0.0	0.0	0.0	0.0	169.8	0.0	364.9	513.4	0.0	0.0	0.0	0.0	0.0	0.0

Appendix J Recharge from Surface Water Irrigation Nanoomo

Year	Alfalfa	Buffalo	Chives	Clay	Daisies	Dwarf	Density	Foothills	Frontier	France	Grasper	Horton	Hoyas	Hollyhock	Kentucky	Kelly	Lavender	Mustards	Parsley	Phlox	Saskatchewan	Willows
1910	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1911	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1912	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1913	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1914	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1915	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1916	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1917	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1918	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1919	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1920	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1921	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1922	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1923	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1924	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1925	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1926	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1927	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1928	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1929	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1930	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1931	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1932	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1933	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1934	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1935	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1936	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1937	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1938	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1939	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1940	0.0	0.0	148.0	0.0	0.0	0.0	189.0	695.0	948.4	291.2	0.0	436.3	265.4	394.6	0.0	0.0	0.0	485.0	0.0	88.8	338.4	365.9
1941	0.0	0.0	148.0	0.0	0.0	0.0	189.0	695.0	948.4	482.4	0.0	481.9	265.4	394.6	0.0	0.0	0.0	485.0	0.0	88.8	338.4	365.9
1942	0.0	0.0	148.0	0.0	0.0	0.0	189.0	695.0	948.4	627.2	1991.2	443.9	265.4	394.6	0.0[1]	0.0	0.0	485.0	0.0	12885.7	338.4	391.3
1943	0.0	0.0	148.0	0.0	0.0	0.0	5735.0	695.0	948.4	627.2	2162.0	394.7	265.4	394.6	6555.0	0.0	0.0	485.0	0.0	12885.7	338.4	391.3
1944	0.0	0.0	148.0	0.0	0.0	0.0	2885.0	695.0	1954.4	648.0	1756.8	896.4	265.0	394.6	6555.0	0.0	0.0	485.0	0.0	12885.7	338.4	391.3
1945	0.0	0.0	148.0	0.0	2885.0	942.4	4307.2	695.0	1954.4	691.7	2566.8	876.3	265.0	394.6	6555.0	6555.4	1760.6	485.0	0.0	12885.7	338.4	391.3
1946	0.0	0.0	148.0	0.0	2885.0	942.4	4307.2	695.0	1954.4	691.7	2566.8	876.3	265.0	394.6	6555.0	6555.4	1760.6	485.0	0.0	12885.7	338.4	391.3
1947	0.0	0.0	148.0	0.0	14997.2	1338.2	6466.8	695.0	1954.4	691.7	2566.8	876.3	265.0	394.6	6555.0	6555.4	1760.6	485.0	0.0	12885.7	338.4	391.3
1948	0.0	0.0	148.0	0.0	14997.2	1338.2	6466.8	695.0	1954.4	691.7	2566.8	876.3	265.0	394.6	6555.0	6555.4	1760.6	485.0	0.0	12885.7	338.4	391.3
1949	0.0	0.0	148.0	0.0	14997.2	1338.2	6466.8	695.0	1954.4	691.7	2566.8	876.3	265.0	394.6	6555.0	6555.4	1760.6	485.0	0.0	12885.7	338.4	391.3
1950	0.0	0.0	148.0	0.0	14997.2	1338.2	6466.8	695.0	1954.4	691.7	2566.8	876.3	265.0	394.6	6555.0	6555.4	1760.6	485.0	0.0	12885.7	338.4	391.3
1951	0.0	0.0	148.0	0.0	14997.2	1338.2	6466.8	695.0	1954.4	691.7	2566.8	876.3	265.0	394.6	6555.0	6555.4	1760.6	485.0	0.0	12885.7	338.4	391.3
1952	0.0	0.0	148.0	0.0	14997.2	1338.2	6466.8	695.0	1954.4	691.7	2566.8	876.3	265.0	394.6	6555.0	6555.4	1760.6	485.0	0.0	12885.7	338.4	391.3
1953	0.0	0.0	148.0	0.0	14997.2	1338.2	6466.8	695.0	1954.4	691.7	2566.8	876.3	265.0	394.6	6555.0	6555.4	1760.6	485.0	0.0	12885.7	338.4	391.3
1954	0.0	0.0	148.0	0.0	14997.2	1338.2	6466.8	695.0	1954.4	691.7	2566.8	876.3	265.0	394.6	6555.0	6555.4	1760.6	485.0	0.0	12885.7	338.4	391.3
1955	0.0	0.0	148.0	0.0	14997.2	1338.2	6466.8	695.0	1954.4	691.7	2566.8	876.3	265.0	394.6	6555.0	6555.4	1760.6	485.0	0.0	12885.7	338.4	391.3
1956	0.0	0.0	148.0	0.0	14997.2	1338.2	6466.8	695.0	1954.4	691.7	2566.8	876.3	265.0	394.6	6555.0	6555.4	1760.6	485.0	0.0	12885.7	338.4	391.3
1957	0.0	0.0	148.0	0.0	14997.2	1338.2	6466.8	695.0	1954.4	691.7	2566.8	876.3	265.0	394.6	6555.0	6555.4	1760.6	485.0	0.0	12885.7	338.4	391.3
1958	0.0	0.0	148.0	0.0	14997.2	1338.2	6466.8	695.0	1954.4	691.7	2566.8	876.3	265.0	394.6	6555.0	6555.4	1760.6	485.0	0.0	12885.7	338.4	391.3
1959	0.0	0.0	148.0	0.0	14997.2	1338.2	6466.8	695.0	1954.4	691.7	2566.8	876.3	265.0	394.6	6555.0	6555.4	1760.6	485.0	0.0	12885.7	338.4	391.3
1960	0.0	0.0	148.0	0.0	14997.2	1338.2	6466.8	695.0	1954.4	691.7	2566.8	876.3	265.0	394.6	6555.0	6555.4	1760.6	485.0	0.0	12885.7	338.4	391.3
1961	0.0	0.0	148.0	0.0	14997.2	1338.2	6466.8	695.0	1954.4	691.7	2566.8	876.3	265.0	394.6	6555.0	6555.4	1760.6	485.0	0.0	12885.7	338.4	391.3
1962	0.0	0.0	148.0	0.0	14997.2	1338.2	6466.8	695.0	1954.4	691.7	2566.8	876.3	265.0	394.6	6555.0	6555.4	1760.6	485.0	0.0	12885.7	338.4	391.3
1963	0.0	0.0	148.0	0.0	14997.2	1338.2	6466.8	695.0	1954.4	691.7	2566.8	876.3	265.0	394.6	6555.0	6555.4	1760.6	485.0	0.0	12885.7	338.4	391.3
1964	0.0	0.0	148.0	0.0	14997.2	1338.2	6466.8	695.0	1954.4	691.7	2566.8	876.3	265.0	394.6	6555.0	6555.4	1760.6	485.0	0.0	12885.7	338.4	391.3
1965	0.0	0.0	148.0	0.0	14997.2	1338.2	6466.8	695.0	1954.4	691.7	2566.8	876.3	265.0	394.6	6555.0	6555.4	1760.6	485.0	0.0	12885.7	338.4	391.3
1966	0.0	0.0	148.0	0.0	14997.2	1338.2	6466.8	695.0	1954.4	691.7	2566.8	876.3	265.0	394.6	6555.0	6555.4	1760.6	485.0	0.0	12885.7	338.4	391.3
1967	0.0	0.0	148.0	0.0	14997.2	1338.2	6466.8	695.0	1954.4	691.7	2566.8	876.3	265.0	394.6	6555.0	6555.4	1760.6	485.0	0.0	12885.7	338.4	391.3
1968	0.0	0.0	148.0	0.0	14997.2	1338.2	6466.8	695.0	1954.4	691.7	2566.8	876.3	265.0	394.6	6555.0	6555.4	1760.6	485.0	0.0	12885.7	338.4	391.3
1969	0.0	0.0	148.0	0.0	14997.2	1338.2	6466.8	695.0	1954.4	691.7	2566.8	876.3	265.0	394.6	6555.0	6555.4	1760.6	485.0	0.0	12885.7	338.4	391.3
1970	0.0	0.0	148.0	0.0	14997.2	1338.2	6466.8	695.0	1954.4	691.7	2566.8	876.3	265.0	394.6	6555.0	6555.4	1760.6	485.0	0.0	12885.7	338.4	391.3
1971	0.0	0.0	148.0	0.0	14997.2	1338.2	6466.8	695.0	1954.4	691.7	2566.8	876.3	265.0	394.6	6555.0	6555.4	1760.6	485.0	0.0	12885.7	338.4	391.3
1972	0.0	0.0	148.0	0.0	14997.2	1338.2	6466.8	695.0	1954.4	691.7	2566.8	876.3	265.0	394.6	6555.0	6555.4	1760.6	485.0	0.0	12885.7	338.4	391.3
1973	0.0	0.0	148.0	0.0	14997.2	1338.2	6466.8	695.0	1954.4	691.7	2566.8	876.3	265.0	394.6	6555.0	6555.4	1760.6	485.0	0.0	12885.7	338.4	391.3
1974	0.0	0.0	148.0	0.0	14997.2	1338.2	6466.8	695.0	1954.4	691.7	2566.8	876.3	265.0	394.6	6555.0	6555.4	1760.6	485.0	0.0	12885.7	338.4	391.3
1975	0.0	0.0	148.0	0.0	14997.2	1338.2	6466.8	695.0	1954.4	691.7	2566.8	876.3	265.0	394.6	6555.0	6555.4	1760.6	485.0	0.0	12885.7	338.4	391.3
1976	0.0	0.0	148.0	0.0	14997.2	1338.2	6466.8	695.0	1954.4	691.7	2566.8	876.3	265.0	394.6	6555.0	6555.4	1760.6	485.0	0.0	12885.7	338.4	391.3
1977	0.0	0.0	148.0	0.0	14997.2	1338.2	6466.8	695.0	1954.4	691.7	2566.8	876.3	265.0	394.6	6555.0	6555.4	1760.6	485.0	0.0	12885.7	338.4	391.3
1978	0.0	0.0	148.0	0.0	14997.2	1338.2	6466.8	695.0	1954.4	691.7	2566.8	876.3	265.0	394.6	6555.0	6555.4	1760.6	485.0	0.0	12885.7	338.4	391.3
1979	0.0	0.0	148.0	0.0	14997.2	1338.2	6466.8	695.0	1954.4	691.7	2566.8	876.3	265.0	394.6	6555.0	6555.4	1760.6	485.0	0.0	12885.7	338.4	391.3
1980	0.0	0.0	148.0	0.0	14997.2	1338.2	6466.8	695.0	1954.4	691.7	2566.8	876.3	265.0	394.6	6555.0	6555.4	1760.6	485.0	0.0	12885.7	338.4	391.3

APPENDIX K

IRRIGATED ACREAGE ESTIMATES

Appendix K – Irrigated Acreage Estimates

Colorado – Estimates of the irrigated acreage for 1940 through 2000 in Colorado for the area covered by the RRCA Model include lands in Kit Carson, Yuma, and Phillips Counties and parts of Sedgwick, Logan, Washington, Lincoln, and Cheyenne Counties. A small area of Elbert County is located in the RRCA Model area, but since there are no irrigation wells or ditches in that area, it was excluded.

The estimates are based on the County Assessors' records of irrigated acreage and well permit information contained in the Colorado Groundwater Commission's Northern High Plains Well Database with adjustments for irrigated fields set aside under federal farm programs. The results were compared to irrigated crop statistics compiled and published by the Colorado Department of Agriculture and the National Agricultural Statistics Service (NASS) and irrigated acreage records for farms participating in federally subsidized programs that were provided by local Farm Service Agency offices through the U.S. Department of Agriculture. Descriptions of these sources and procedures follow:

County Assessor Records

The county assessor is an elected official in county government and their duties are prescribed by Colorado Revised Statutes. Succinctly, the county assessor must discover, list, classify, and value all taxable real and personal property within their respective county. Procedures for classifying and valuing property are set forth in the "Personal Property Valuation Manual", the "Land Valuation Manual", and other references prepared by the

Colorado Division of Taxation. The assessor's appraised property values form the basis for taxing districts to set mill levies and taxes. The county treasurer is responsible for collecting all property taxes.

For agricultural land, the assessor must determine the value of the land based on its production capability by considering soils, irrigation sources and methods, crop yields, crop values and farm sales. The assessor relies on aerial photographs, county clerk records, the county soil survey, agricultural statistics from NASS, climatalogical records, interviews with local farmers, and other locally available information. Since 1989, all property is appraised every other year based on sales of equivalent property during the preceding two years. Provisions are allowed to conduct interim appraisals if necessary to reflect a change in property values assessment such as conversion from irrigated cropland to dry land pasture.

The county assessors must publish an "Abstract of Assessment" by August 25 of each year that summarizes the amount and value of various categories of property as of the previous 1st of January. The abstracts also document the valuation, mill levy, and revenue for each taxing district in the county. Categories of property include irrigated farmland, meadow hay land, dry farmland, grazing land, and other agricultural land. Since 1993, the abstracts tabulate acreage by sprinkler and flood irrigation. The Colorado Department of Local Affairs summarizes the abstracts and submits an annual report to the Colorado General Assembly.

Irrigated land that is taken out of production due to farm programs, such as the Payment in Kind (PIK) and Conservation Reserve Program (CRP), remain classified as

irrigated by the county assessor pursuant to requirements in federal authorizing legislation for these programs. They remain classified as irrigated to assure payment to the farm owner by the federal government is commensurate with irrigated land production capability and to maintain the assignment of tax burden. The Farm Service Agency (FSA) of the US Department of Agriculture (USDA) administers the federal crop programs. Each year, program participants must report crop acreage to the local FSA office that compiles records of irrigated and non-irrigated croplands. Federal farm program acreage records for 1990 through 2000 were available and summarized for each county as CRP fields and fallow fields. Those annual values were deducted from the assessors' irrigated acreage. The PIK Program reduced irrigated acreage significantly in the 1980s. Since the USDA does not retain records for more than 10 years, Colorado estimated the PIK acreage using NASS records as described later in this document.

Colorado Groundwater Commission's Northern High Plains Well Database

The Northern High Plains Well Database covers the entirety of the RRCA Model area in Colorado. The information contained in the well database for the model area includes 3,967 groundwater well records. Each record includes the well location, use of the water, place of use, pumping rate, irrigated acreage, owner, and priority date. The records for each county were sorted by use, priority date, and location. For each county and priority year, the number of irrigation wells is counted and the acreage shown on the well permits is quantified.

The irrigated acreage identified in the well permits exceeds the actual irrigated acreage identified through County Assessor data. Review of well permit acreage information indicates most cite a square quarter-section of land, or 160 acres. Center-pivot sprinkler systems are the prevalent water application method in the model area and a typical circular quarter-section system irrigates only 130 acres. Comparison of permitted irrigated acreage with NASS data also indicates the well permit information exceeds the irrigated crop acreage reported by NASS.

Estimate of Surface Water Irrigated Acreage in Colorado

Surface water irrigation in the Basin in Colorado occurs only in Yuma and Kit Carson Counties. The surface water acreage was obtained from the respective County Assessor's records that documented a total of 2,902 (Yuma) and 1,861 (Kit Carson) acres in 1940. These quantities were carried forth to date and do not reflect the small decrease in surface water irrigation that has occurred since 1940.

Estimate of Irrigated Acreage by County Over Time in Colorado

The assessors' records of irrigated acreage for Kit Carson and Yuma Counties include land irrigated from surface water sources that precede 1940. Irrigation of additional acreage after 1940 can be attributed exclusively to groundwater development. Review of historic county assessor records confirms there has been little change in irrigated acreage since 1979 and the Assessors' records for recent years provide the most accurate quantification of irrigated acreage in each county.

To estimate the irrigated acreage over time, the ratio of the assessors reported acreage in 2000 to the cumulative acreage under all well permits for irrigation is calculated. For Phillips, Sedgwick, Logan, Washington, Lincoln, and Cheyenne Counties, that ratio is multiplied by the annual cumulative well permit acreage to determine the acreage in a specific year. For Kit Carson and Yuma Counties, the ratio was multiplied by the yearly permitted acreage and the resultant was added to the previous year's acreage to account for surface-water irrigated land developed before 1940. For 1990 through 2000, the fallow irrigated fields and fields idled due to farm programs (USDA records) were deducted from the calculated acreage to determine the net irrigated acreage for those years. From 1982 through 1988, significant acreage was taken out of production through the USDA's Payment in Kind (PIK) program. The USDA represents that it does not have records of the county acreage idled by this program during the 1980's because it retains records on individual farms for only 10 years. The NASS records show significant reductions in irrigated acreage, up to 110,000 acres in 1983, in Kit Carson, Yuma, and Phillips Counties. To reflect this program, Colorado combined the NASS acreage for the three counties[1] and calculated the annual reduction percentage from the acreage in 1981.

[1] The NASS records for the other five counties were not used for these calculations because the irrigated acreage in these counties overlaps into other river basins.

Year	Total Irrigated Acres	Reduction as Percent of 1981
1981	507,774	0.0
1982	480,443	5.4
1983	392,562	22.7
1984	426,248	16.1
1985	431,243	15.1
1986	416,416	18.0
1987	465,633	8.3
1988	468,627	7.7

The annual reduction percentages were multiplied by the irrigated acreage in each county and the resultant was subtracted to determine net irrigated acreage.

Kansas – The irrigated acreage in Kansas was determined from an analysis of available data from the water use reports, NASS, Census of Agriculture, and tabulations of water rights and groundwater wells. For the period 1989-1999, irrigated acres from the Water Use Reports were used. In addition to acreage data, crop information was used to develop countywide crop distributions for computing crop irrigation demand over the entire study period.

The NASS data for agricultural statistics provide countywide data that is the most complete in Kansas after 1972, and was used as the basis for the acreage estimates for the period of 1972-1988. However, some irrigated crops are not tracked individually in these records. The Census of Agriculture data from 1987, 1992 and 1997 were used to distribute some acreage to irrigated crops from the total crop acreage given in the NASS data. The percentage of each county's irrigated acreage included within the model domain was determined from the Water Use Report data

and multiplied by the countywide irrigated acreages determined from the NASS data and Census data. For the pre-1972 acreage, the annual well count was multiplied by a ratio of acres per well derived from either the Water Use Reports or the adjusted NASS data for 1972, whichever gave a better fit to the subsequent year's estimates.

Irrigated acreage for each section was calculated by multiplying the annual well count by the irrigated acres per well, with a maximum of 520 irrigated acres per section. All remaining acreage above the 520 acre limit was assigned pro rata to other sections in the county.

Nebraska – In cooperation with the Nebraska Department of Agriculture (NDA), NASS prepares an estimate of crop acreage by county. Annually they produce "Nebraska Agricultural Statistics" which is a compilation of information about farms, crops, and livestock. Every five years, NASS produces the Census of Agriculture, which is a detailed counting of farms, crops, and livestock. For the intervening four years, the estimates are prepared using a much smaller sample than the census. Periodically, NASS presents revisions to the annual estimates based on the results of the most recent census.

Reports are prepared annually for Nebraska and the data are collected and summarized statewide and by county. Farmers are surveyed each fall following harvest. Those surveys are supplemented with surveys of grain elevators and mills for volumes of grain received, meat packing plants, and other agribusiness. Crops are added and deleted from the annual report as cropping patterns change. For example, broom corn was deleted from the surveys in the 1960s and sunflowers were added in 1990. Generally, the USDA is most interested in farm program

crops such as corn and wheat and the NDA is interested in other crops such as alfalfa, grass hay, fruits, and table vegetables.

The annual reports break out irrigated and non-irrigated acreage for some crops. For other crops, such as alfalfa and corn for silage, NASS reports total acreage harvested every year but reports irrigated acreage periodically. In these cases, estimates of the irrigated acreage for the crop is based on the ratio of reported irrigated acreage and total harvested acreage in other years.

Appendix K Irrigated Acreage Colorado

Year	Cheyenne	KitCarson	Lincoln	Logan	Phillips	Sedgwick	Washington	Yuma
1918	0	0	0	0	0	0	0	0
1919	0	0	0	0	0	0	0	0
1920	0	0	0	0	0	0	0	0
1921	0	0	0	0	0	0	0	0
1922	0	0	0	0	0	0	0	0
1923	0	0	0	0	0	0	0	0
1924	0	0	0	0	0	0	0	0
1925	0	0	0	0	0	0	0	0
1926	0	0	0	0	0	0	0	0
1927	0	0	0	0	0	0	0	0
1928	0	0	0	0	0	0	0	0
1929	0	0	0	0	0	0	0	0
1930	0	0	0	0	0	0	0	0
1931	0	0	0	0	0	0	0	0
1932	0	0	0	0	0	0	0	0
1933	0	0	0	0	0	0	0	0
1934	0	0	0	0	0	0	0	0
1935	0	0	0	0	0	0	0	0
1936	0	0	0	0	0	0	0	0
1937	0	0	0	0	0	0	0	0
1938	0	0	0	0	0	0	0	0
1939	0	0	0	0	0	0	0	0
1940	115	359	96	156	800	0	202	3681
1941	115	359	109	156	800	0	410	3929
1942	115	359	109	156	1115	0	410	3929
1943	115	359	109	156	1115	0	410	3929
1944	115	359	109	156	1115	0	570	3929
1945	365	359	109	156	1115	0	780	3929
1946	365	359	109	156	1115	0	972	4049
1947	365	715	129	156	1115	0	1256	4449
1948	365	1939	874	156	1235	0	1908	3885
1949	445	3284	1054	156	1812	160	2172	5425
1950	540	3580	1083	156	1872	160	2810	5590
1951	540	4105	1083	156	2092	390	2810	7293
1952	640	4425	1083	156	2380	390	2920	7856
1953	780	5011	1213	156	2520	390	3316	8690
1954	780	7784	1213	156	2950	390	3436	10442
1955	852	17556	1213	188	3260	390	3841	13553
1956	852	21381	1245	188	3460	550	3716	17189
1957	852	23815	1245	346	3616	760	4138	19111
1958	852	24931	1365	348	3984	760	4198	20001
1959	852	27570	1365	348	4102	760	4218	20366
1960	852	29560	1365	444	4428	760	4330	20966
1961	868	33346	1365	444	4777	760	4643	22210
1962	1028	40350	1365	444	4937	760	4824	24080
1963	1132	58033	1401	604	5788	1000	5634	28129
1964	1952	79492	1886	604	10294	1004	5935	37546
1965	2668	105305	1878	604	14814	1004	8091	57473
1966	2668	117845	1878	604	19595	1004	10020	82850
1967	2908	131198	1878	604	30143	1454	14794	126366
1968	3348	138790	1947	1244	33939	2568	17758	150159
1969	3748	147790	2147	1404	41862	4126	20071	187573
1970	4296	153155	2307	1404	46823	4126	20769	195127
1971	4850	158049	2517	1404	49588	4786	23309	201318
1972	5875	161826	2677	1708	51803	5396	24351	218195
1973	6531	172870	2837	2166	56760	8135	28612	236897
1974	8722	182301	3157	4536	65518	17658	32344	263105
1975	10434	185362	3672	5686	69468	21963	37786	282978
1976	11304	186572	3872	5980	72877	24051	39895	301678
1977	11844	186572	3952	6310	74051	24341	40595	305361
1978	11898	187282	3992	6310	74460	24573	41585	308720
1979	11898	187512	3992	6310	75673	24740	41851	311525
1980	11898	187512	3992	6310	75804	24742	41781	312125
1981	12098	187512	3992	6310	75860	24740	41781	312175
1982	12098	187512	3992	6310	75886	24731	41781	312487
1983	12098	187512	3992	6310	75814	24731	41781	312499
1984	12098	187822	3992	6470	76186	24760	41781	313378
1985	12098	187822	3992	6730	76324	24756	41781	312832
1986	12098	187870	3992	6810	76287	24732	41781	313462
1987	12098	187870	3992	6810	76310	24733	41781	313483
1988	12098	187870	3992	6810	76332	24733	41781	313450
1989	12098	187870	4084	6810	76347	24740	41781	313640
1990	12098	187670	4148	6810	76369	24738	41781	313740
1991	12098	187770	4148	6810	76382	24738	41921	313766
1992	12098	187770	4148	6810	76381	24741	41921	313707
1993	12098	187770	4148	6810	76343	24740	41921	313758
1994	12098	187770	4148	7018	76367	24744	41921	312950
1995	12098	187770	4148	7018	76385	24747	41921	313731
1996	12098	187770	4148	7018	76385	24746	41930	313762
1997	12098	187770	4148	7018	76389	24739	41930	313793
1998	12098	187770	4148	7018	76389	24745	41930	313772
1999	12098	187770	4148	7018	76375	24745	41930	313757
2000	12098	187770	4148	7018	76381	24748	41930	313800

Appendix K Irrigated Acreage Kansas

Year	Cheyenne	Decatur	Gove	Graham	Jewell	Logan	Norton	Phillips	Rawlins	Sheridan	Sherman	Thomas	Trego	Wallace
1918	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1919	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1920	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1921	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1922	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1923	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1924	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1925	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1926	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1927	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1928	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1929	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1930	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1931	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1932	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1933	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1934	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1935	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1936	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1937	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1938	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1939	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1940	480	288	0	0	553	0	264	661	264	226	115	110	0	0
1941	974	333	0	0	563	0	264	661	388	226	174	110	0	0
1942	1334	335	0	0	563	0	264	661	388	226	174	110	0	0
1943	1694	335	0	0	563	0	264	661	388	226	174	110	0	0
1944	2054	336	0	0	563	0	264	661	388	226	174	110	0	0
1945	2054	337	0	0	563	0	264	661	388	226	174	110	0	0
1946	2054	336	0	0	563	0	264	661	388	226	174	110	0	0
1947	2054	356	0	0	563	0	264	661	388	226	289	110	0	0
1948	2054	356	0	0	553	0	376	661	388	226	289	220	0	0
1949	2054	358	0	0	553	0	376	661	388	226	519	220	0	0
1950	2054	398	0	0	553	0	446	761	658	356	634	220	0	0
1951	2054	499	0	0	563	0	446	761	658	356	634	440	0	0
1952	2054	456	0	0	1002	0	446	761	658	356	1669	550	0	0
1953	2054	587	0	0	1002	120	446	1081	1018	746	2247	660	0	0
1954	3264	527	0	280	1002	120	866	1561	1108	748	2584	880	200	0
1955	3744	1065	180	390	1002	120	1006	2661	1848	1916	4200	[illegible]	200	0
1956	5064	1581	450	520	1257	120	1216	3461	2278	4304	6958	[illegible]	600	150
1957	7104	2018	540	820	1257	240	1404	3561	2818	6912	8571	[illegible]	800	150
1958	7587	2097	630	520	1257	240	1404	4158	2998	7692	9645	[illegible]	1000	150
1959	7947	2238	720	650	1257	240	1614	4158	3268	8862	10341	[illegible]	1000	150
1960	9387	2644	720	780	1257	240	1754	4158	3268	9122	10873	5830	1000	150
1961	10323	3217	720	910	1257	360	1824	4367	3448	9512	12311	6180	1000	150
1962	10928	3429	990	910	1257	360	1964	4367	3628	10032	14508	6710	1000	150
1963	12690	3329	1260	910	1257	600	1964	4488	3718	10942	19135	7480	1200	150
1964	15717	3623	1350	910	1257	1200	2012	4568	4078	13032	24886	9470	1300	300
1965	18437	4211	1890	1820	1257	1680	2642	4658	4528	16710	31028	13430	1400	450
1966	20028	4348	2970	1820	1257	1800	2712	4758	4664	17680	33958	14640	1400	750
1967	21748	4573	3960	2080	1257	3000	6986	6657	5698	21000	40228	17080	1400	750
1968	24486	4833	5490	2210	1257	4320	7256	6657	6508	26696	49372	22530	1700	1200
1969	26121	5391	6860	2340	1257	5280	7413	6896	7228	31318	56441	24730	1700	1200
1970	27220	5798	7110	2470	1257	5760	7578	6896	7948	34828	58620	26250	2000	1200
1971	29033	6146	8280	2730	1257	6240	7935	9159	8308	38468	61173	29220	2000	1200
1972	31485	6298	10443	4313	1293	6664	8584	9229	9580	40418	61158	34831	1931	1480
1973	31563	9283	12986	5208	1246	6707	10021	9227	14967	49692	68540	40810	1948	1458
1974	31479	8121	16033	5168	1257	6887	9128	9676	12673	52349	70316	51167	2508	1884
1975	34479	10458	17279	5724	1242	9923	8914	9099	14639	58351	84256	62295	2916	2205
1976	37682	10456	18334	7182	1177	8021	9084	9058	13186	62477	97592	80668	2246	2657
1977	43236	10616	15695	9472	1258	9512	9562	9532	15008	71867	106831	86616	2732	2956
1978	39422	10903	14947	10983	1288	8284	9554	9499	15760	65269	103137	84508	2047	2501
1979	38413	10475	14090	9106	1442	7563	8909	5485	15308	66896	10[illegible]	80075	2458	2737
1980	34863	9821	11562	5855	1410	6168	10836	9702	11852	61404	11[illegible]	68255	1561	2847
1981	38493	11747	14423	8659	1521	8084	5611	5510	13991	68693	11[illegible]	95243	2356	3275
1982	40852	11811	21048	10882	1569	9818	7152	5178	17238	76383	114632	93032	3138	2510
1983	32584	11974	15027	7981	1484	8870	4898	3773	12429	52528	101744	66719	2508	1686
1984	31681	14063	18182	9785	1582	7620	8347	4857	13780	73809	104223	86802	2632	2174
1985	34174	15245	17628	12849	1600	6956	8615	6287	15194	71823	103452	98646	2230	2309
1986	37296	14564	20019	12768	1665	6270	10848	10293	14745	73786	95651	107830	2913	2979
1987	41880	8651	18436	7808	1562	4750	9926	10175	16871	68421	86350	98032	1980	2038
1988	38343	8209	14281	6113	1466	5745	9680	9494	17135	65075	91734	80341	2170	1887
1989	42826	10822	14296	6973	1459	7584	10253	9557	17443	74246	105567	99335	1832	2124
1990	44402	10830	13110	7708	1475	7298	10580	9811	17217	72549	108985	96888	1734	2177
1991	44347	11467	14167	8184	1555	7488	7740	5117	18114	73286	107197	98506	2008	2143
1992	42444	8283	12573	7509	1516	6912	7128	6038	14507	67375	103403	92546	1836	2241
1993	44082	8735	10396	5800	1237	7104	9889	9368	15186	67586	105581	94917	1280	2022
1994	48051	10333	14362	7896	1610	7488	10019	10305	17741	71513	110483	98855	2065	2249
1995	43236	11068	14164	8086	1588	7275	10288	10531	19088	71925	103838	86308	2135	1969
1996	47041	10326	14509	8749	1575	7568	10019	9714	17104	73562	115284	98978	2100	2238
1997	48606	11463	14583	9127	1619	7953	10814	10403	17715	75133	119869	99838	1944	2002
1998	47797	10540	15416	9813	1563	7857	10328	9469	17970	75656	119856	98451	2340	2087
1999	47734	10302	14381	10109	1570	7546	10432	9896	17071	75458	114338	99047	2288	2254
2000	48619	11698	14931	10408	1305	7644	11013	9862	18743	78728	115884	102013	2384	2426

Appendix K Irrigated Acreage Nebraska

Year	Adams	Buffalo	Chase	Clay	Dawson	Deuel	Dundy	Franklin	Frontier	Furnas	Gosper	Hall	Hayes	Hitchcock	Kearney	Keith	Lincoln	Nuckolls	Perkins	Phelps	Red Willow	Webster
1918	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1919	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1920	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1921	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1922	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1923	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1924	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1925	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1926	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1927	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1928	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1929	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1930	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1931	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1932	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1933	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1934	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1935	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1936	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1937	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1938	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1939	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1940	91	0	736.2	0	2929.9	946.8	384	476	190	630	946.7	256.9	297	1582	2089	1857	2027	89	199	3772	703	290
1941	91	0	914.2	0	3557.1	946.8	384	544	190	746.3	1388.4	543	297	1846	2749	2175	4040	134	199	4880	913	290
1942	91	0	1003.2	0	4103.9	808.6	480	680	190	798.7	7073.4	543	297	2099	27206	2946	4234	134	297	46241	1009	290
1943	91	0	1181.2	0	4364.5	908.4	5014	680	190	870.7	7743.8	804.8	297	2201	27375	2983	4748	134	297	46834	1201	290
1944	91	0	1524.8	0	4480.1	908.3	3110	748	190	951.7	7745.3	730.3	390	2414	28282	2881	4924	134	297	46781	1629	290
1945	91	0	1524.8	0	18490.6	2511.4	3397.9	1019.9	190	992.4	7821	920.4	390	2414	28582	11336	6247	134	297	46875	3018	290
1946	91	0	1710.8	0	18887.9	2561	3546	1291.8	285	1239.2	7910.2	1626.8	547	2798	31682	11731	7065	134	297	47389	3139	304
1947	544	0	1799.8	0	18917.8	2730.7	3546	1429.8	330	1741.5	7984.9	2539.9	547	8150	33722	12542	8781	607	297	47989	3153	730
1948	1038.1	0	1977.8	0	19421.3	2730.1	3546.9	1833.7	573	1814	8156.1	2778.2	547	7100	35306	12726	12089	805	584	48410	3243	910
1949	1082	0	2403.2	0	19770.9	2730.3	3625.1	1778.8	660	2721	8394.7	2674	922	7940	36124	12806	11723	1125	920	48835	3280	731
1950	1170	0	2736	0	19887.4	2730.5	4800.3	2982.9	2814.7	3731.7	8801.5	3119.3	715	8582	37273	13107	20230	1040	702	49582	3679	1008
1951	1344.5	0	3470.8	0	20086.9	2730.4	4883	4203.8	1294.9	9352.8	8466.9	4378.5	1123	8986	37914	13373	19751	1423	891	50227	3998	1372
1952	1432.5	0	3743.8	0	20245	2910.2	5487.3	3878.1	1883.4	9549	8484.1	3927.5	1299	10091	38889	13549	18254	4710	1169	50418	13128	1540
1953	1729.8	0	4894.8	54.3	21310.4	2988.8	6221.7	5002.1	2642.3	9808.8	8252	4844.4	1547	12752	48408	14092	19539	5048	1787	53841	6048	1957
1954	2511.3	0	6829.1	30.9	22203.7	3088.3	6448.3	7829.2	4291.4	10229.9	14806.3	6316.6	1866	13579	51310	14857	25282	6139	2378	57387	6245	3230
1955	3244.6	0	9037	30.9	23867.1	3209.1	10467.3	10981.7	5840	10566.7	17073.9	8791.8	2738	13226	50888	15679	27829	7475	2988	71049	10628	4184
1956	4886	0	10241.1	134.2	26348.7	3268.2	11734.8	13794.4	7822.8	12738.3	18843.1	10783	2731	14284	52783	16238	24289	8346	3180	79108	12140	5373
1957	7089.7	0	9304	298.9	24936	3380	9378.7	17881.7	10161.8	18111	18848.4	12138.2	3886	17125	56110	14066	26485	9222	3889	74089	14685	8105
1958	7378.5	0	9741	297.4	24270.2	3431	8790.8	18213.5	9934.7	21229.4	19850.7	12417.2	3918	18876	55844	10852	23448	9224	4298	71933	14843	9148
1959	7586.4	0	11169.4	334.2	26084.3	3865.4	9495.8	21727	10379.4	21742	20845.8	14603.8	3422	15894	72543	11400	25364	8829	4802	81342	16218	8561
1960	8212.9	0	10867.2	348.8	31867.5	3809.9	14821.2	28102.8	12682.8	24186.7	24544.6	16818.5	4237	20131	78102	14323	29348	10211	4991	88627	19744	9503
1961	7983.8	0	12368.8	252.7	27788.7	3608.9	12324.8	22398.1	11284.3	25384.8	21323.4	15237.2	4854	18742	80087	14538	24773	8881	4888	85488	19833	8917
1962	7239.7	0	12038.7	299.8	21187.9	3629.7	11436.8	20466.2	10439.3	23915	20560	14465	5237	22174	84971	14494	25507	9267	4888	82878	21370	7341
1963	8181.8	0	14467.2	331.8	28508.8	3980.8	14821.4	24479.8	12407.3	28774.8	22846.4	18211.4	5811	23810	87954	15268	25500	10035	4986	88868	24274	9067
1964	8082.7	0	16808.3	367.3	34310.6	3748.4	17208.6	21779.4	12586.8	21708	21840.2	15632.2	5532	18092	90775	13867	27983	9539	4481	84379	26348	8667
1965	8631.7	0	18429.2	374.5	23771.8	3747.1	21213.4	22515.8	13196.2	21519	20333.8	16118.8	5843	18843	87871	13237	27382	9118	5183	86801	27186	8546
1966	10031.8	0	23114.1	526.8	28466.8	3809	23864.9	25678.1	14881.2	21838.4	23228.5	19060.8	6299	19109	75866	14795	24228	9530	5629	101408	27362	10071
1967	11806.3	0	32293.3	539.1	25960.8	3932.7	22166.5	30080.8	17299.3	28863	28733.8	22517.7	6309	20752	83203	16189	30718	10014	6603	99880	30843	11429
1968	11925.8	0	38204.8	580.5	24845.1	4054.8	23435.8	31828.8	18739.4	28883.8	29748.5	23043.8	7483	19483	86137	18110	27861	10419	10613	102389	30425	11400
1969	11188.8	0	37911.7	594.4	25471.7	4112.3	25383.3	29481.8	20230.1	29855.3	29771	29521.3	8098	18433	87853	17875	29219	10288	11182	119079	31099	12586
1970	12582.9	0	44302.3	988.3	25346.5	4113.8	30458.1	32530.9	24807.8	29367.2	34087.3	34427.1	9775	20423	89041	19881	31259	11986	13642	119681	35308	14225
1971	13613.4	0	57338.8	1000.1	27391.5	4176.2	34278.2	34565.2	24582.7	31801.8	34251.8	35087	10882	24533	102884	19867	33748	11362	15672	130116	39824	16022
1972	12901.8	0	67191.3	908.4	28781	4235.2	36288	32622.4	27086.3	30757.2	37484.2	36183.8	12361	22451	104887	22001	34248	10805	20549	127980	39531	14489
1973	13609.7	0	78179.5	1129.5	31705.8	4381.7	38847.9	39587.2	30984.5	36104.4	40134.3	39088.5	12329	24347	117760	23402	39899	11983	26213	136469	43103	16348
1974	15270.6	0	87977.3	1171.9	36288.3	4422	40447	41077.4	40388.4	34885.7	45293.8	42411	13447	25758	120533	25472	50286	13534	43741	146560	42984	15736
1975	18008	0	98018.8	1348.8	36884.6	4428.8	51478.8	40808.8	51240.3	37813.5	48826.3	44566.7	15915	30222	129170	31127	51884	13275	64384	154802	50194	20460
1976	17802.1	0	98648.5	1404.2	39834.3	4429.6	54029.5	54404	54189.9	43887.7	45405.2	48550.2	16250	29907	136878	30647	61286	14382	68024	160448	50855	23741
1977	20706.8	0	124469.9	1484.9	39823.9	4431.1	57056.7	62878.1	60121.7	43836.1	58473.2	58187.8	22429	30349	154293	34231	74504	13634	79877	187980	64723	29991
1978	21132.4	0	138361.1	1539.8	37431.4	4491.6	77871.7	84748.8	83186.3	43827.1	69790.7	68768.6	32008	30873	146949	35798	80242	15077	87022	184883	84588	31232
1979	22787.3	0	142902.1	1589.5	40896.2	4818.2	82828.4	90830.7	88126.7	48084.8	58126.7	58432.3	34208	33884	153236	40284	85872	15337	101736	188042	84382	32074
1980	24480.8	0	148918.8	1762.5	42984.9	4859.7	74830.3	88084.3	98027.1	50187.8	98832.5	70867.8	34132	34204	173629	41978	88215	17183	109816	212227	88809	34111
1981	24858.8	0	142980.2	1857.8	43980.7	4858.7	78698.5	90820	99413	48480.8	92878.9	80643.3	38428	37052	179491	42908	110156	18321	112800	212273	90384	36710
1982	24097.8	0	150830.3	1986.3	42834.4	4861.3	76801.2	71131.8	84191.1	42427.8	80729	88474.4	33482	33618	170191	44130	97284	14436	103624	221394	84287	35982
1983	18134.1	0	100878.1	1271.1	30867.4	4553.2	52980.2	46731.9	50412.8	37877.8	40988.4	41801	30430	24674	111185	39130	72625	12120	90706	141438	38388	23281
1984	22378.1	0	143389.9	1580.6	43460.7	4671.8	69850.8	67094.8	71023.8	45828.3	53398.3	54313.1	36118	34680	172185	50548	107843	17684	140847	213984	48146	31727
1985	22984.4	0	139883.7	1808	48884.3	4874.8	82187.2	70565.4	71183.5	45825.4	62354	64808.3	40945	37736	170432	53323	110832	18847	156324	220946	54836	31914
1986	23255.8	0	131467.8	1756.2	42828.8	4886.1	68474.9	71380.7	83644.3	46729	54781.5	57585.4	36329	30838	169114	48541	97451	19980	139841	198230	46829	29972
1987	21675.8	0	153961	1588.2	39298.4	4884.9	60299.1	64829.3	59656.3	43116.2	54008.2	50187.8	32495	29898	152540	41034	83974	18427	110556	192637	51805	27311
1988	23146.9	0	139294.2	1831	42948.3	4853.5	77789.6	68286.2	55782.4	41668.7	50879.5	58483.8	29152	29083	156852	42998	88736	14602	110442	203621	50549	32784
1989	28126.3	0	145921.3	1734.8	44289.8	4848.8	87798.1	73832.1	63186.7	52247.3	57544.3	65792.7	29532	28438	183427	43015	103051	14824	119589	229312	53961	34389
1990	29897.3	0	169831.7	1782.8	44278.8	4860.8	89190	73371.7	61698.1	50211.1	58518.8	67828.8	31540	30814	182412	47184	108252	15006	117733	232014	57467	34834
1991	27531.8	0	165325.1	1778.5	44801.2	4580.9	82413.7	74379.3	60495.3	49157.3	70980.4	66367.8	34189	32189	184200	47008	109104	15978	118462	237988	55672	36793
1992	27560.5	0	164480.5	1771.1	47221.9	4558.8	84010.2	74620.7	60837.3	49818.8	68108.7	68295.8	33662	29838	188482	42743	109426	16310	123824	224340	54805	37928
1993	26948.8	0	147971.9	1721.5	42525.9	4553	82871	74431.9	59894.2	44728.4	69848.5	64547.9	27373	29826	174338	42181	101380	16381	123611	214104	54564	36359
1994	27963.5	0	157313.1	1786.4	44230.3	4654.9	85927.3	79188.8	58579	50573.2	68578.5	67223.3	34107	28323	189884	44525	111846	16847	129118	241873	56211	41129
1995	27560.5	0	156750.9	1752.9	43557.5	4813.4	88491.4	74389.9	53188.1	48838.5	66560.2	67304.3	32530	23984	189840	44504	114800	17856	133297	232077	54582	39043
1996	27988.6	0	166681.6	1819	47806.6	4854.8	88498.4	78178	61825.5	51187.7	71178.1	70359.2	33294	29108	192540	48043	123276	18150	132746	239142	56941	40313
1997	28983.9	0	169136.8	1854.2	44115.2	4567.7	88184.2	85382.2	60123.7	54238.5	71383.4	69229.9	39488	30873	180137	49870	125117	17821	129295	239884	58849	37708
1998	29110.7	0	158845	1856	43388.6	4558.9	83431.2	82788.9	53447.9	52648.2	74398.6	69115.5	38629	29988	181820	50800	125084	18879	137964	232870	57342	45798
1999	29362.2	0	161675.7	1850.2	44839.5	4497.2	77586.6	84467.9	53331	48702.2	72385	74278	39600	29808	188900	54200	129056	21662	134191	229287	58045	46494
2000	30012.9	0	166386.4	1981.8	48452.7	4498.1	84787.1	88423.3	58717.8	50434.2	78230.3	79825.1	44337	32213	200787	49187	128341	19891	134275	245886	58183	49852

APPENDIX L
CROP IRRIGATION REQUIREMENTS

Net Crop Irrigation Requirement

(potential consumptive use minus effective rainfall minus gain in soil moisture from winter and spring precipitation) (inches)

	County (or portion of County in the Republican River Basin study area)							
Year	Cheyenne	Kit Carson	Lincoln	Logan	Phillips	Sedgwick	Wash-ington	Yuma
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
1940	12.55	13.86	14.82	11.21	10.94	10.67	17.73	10.32
1941	13.55	16.46	17.25	13.54	13.29	13.28	17.15	13.07
1942	18.94	18.56	19.71	22.26	22.39	21.91	19.81	20.34
1943	20.27	18.26	19.22	20.08	20.14	19.57	20.35	18.21
1944	13.56	13.46	13.86	10.25	9.74	9.62	14.95	11.84
1945	20.11	17.71	18.91	17.58	17.34	17.07	16.80	15.28
1946	18.05	17.32	17.76	17.04	17.36	16.92	22.95	15.82
1947	12.69	13.47	17.52	21.50	22.57	22.56	19.30	14.00
1948	11.13	13.18	15.56	15.13	14.97	14.78	12.41	12.79
1949	16.95	16.83	17.30	17.78	17.53	17.82	14.03	12.74
1950	17.89	12.46	14.23	11.88	11.84	12.13	13.80	12.00
1951	22.10	19.74	23.10	24.55	26.55	24.26	20.27	22.55
1952	19.30	18.18	21.04	19.50	20.21	18.54	18.27	21.81
1953	20.05	23.88	27.01	20.16	20.44	19.57	22.36	20.62
1954	20.81	18.43	22.87	19.18	18.46	19.31	16.38	16.77
1955	26.02	24.74	25.93	22.88	22.52	22.62	21.77	19.39
1956	15.54	14.30	15.21	20.89	20.84	20.83	16.67	15.88
1957	11.09	14.72	13.60	16.25	16.77	14.27	18.18	14.65
1958	15.16	23.44	24.10	21.13	20.70	20.71	20.40	19.29
1959	17.61	19.91	18.99	21.57	20.64	20.84	20.82	16.13
1960	13.90	18.48	18.06	18.18	17.33	17.07	16.40	13.83
1961	16.46	16.06	17.72	16.74	15.86	15.58	18.39	10.51
1962	20.89	19.50	23.06	21.23	20.51	19.01	18.84	16.99
1963	20.57	20.41	22.21	24.34	22.74	23.40	20.69	19.86
1964	13.25	9.75	9.94	14.51	13.96	13.96	15.31	11.20
1965	17.25	17.84	19.08	16.74	15.53	15.12	17.97	12.28
1966	16.93	16.38	15.58	15.10	14.77	14.93	16.12	15.91
1967	19.11	19.40	19.31	22.21	21.22	20.23	18.47	16.53
1968	14.33	19.97	19.40	20.15	18.79	18.92	17.64	16.70
1969	17.18	21.22	20.99	24.27	21.68	22.09	18.49	18.23
1970	18.85	21.78	19.96	18.54	17.10	17.36	19.49	19.21
1971	16.95	18.21	16.61	17.25	16.93	16.20	16.75	16.42
1972	18.99	19.65	16.79	19.37	18.08	18.01	16.51	13.71
1973	23.06	23.48	21.00	24.60	23.81	23.16	22.13	20.98
1974	19.37	20.19	19.33	21.44	20.81	20.24	17.43	19.29
1975	19.75	23.49	22.01	23.97	23.75	22.61	19.80	19.52
1976	20.28	19.84	16.88	20.08	20.05	19.64	22.98	18.22
1977	20.15	19.19	18.89	25.28	25.29	24.80	18.67	22.18
1978	18.49	15.72	13.31	18.19	18.54	18.30	15.37	18.06
1979	18.31	17.29	16.97	22.17	21.31	22.01	18.76	16.35
1980	17.01	19.08	17.16	18.47	18.33	18.43	17.41	17.50
1981	16.71	14.89	13.49	14.85	14.69	14.80	14.95	13.94
1982	21.54	15.43	17.40	20.81	20.07	20.08	18.05	17.56
1983	19.77	19.02	20.57	22.81	21.56	21.76	18.20	20.91
1984	18.68	15.43	14.99	21.22	20.99	19.52	18.25	15.92
1985	18.31	18.79	19.55	20.97	20.43	19.79	19.12	18.85
1986	17.20	15.67	16.18	18.29	18.61	18.37	15.40	18.04
1987	18.46	18.15	18.54	20.10	20.20	20.20	19.07	20.18
1988	13.14	16.31	16.64	15.41	14.96	15.55	16.42	14.45
1989	17.60	19.56	18.72	19.82	18.51	19.06	15.25	15.73
1990	16.82	16.05	15.62	17.89	18.70	18.72	19.62	13.04
1991	17.63	16.77	17.07	16.76	16.32	16.85	17.57	14.78
1992	19.48	16.02	15.86	13.38	13.14	13.48	16.82	14.38
1993	18.64	17.43	16.88	22.77	22.63	22.76	24.45	16.86
1994	17.09	15.10	14.26	17.23	17.11	17.63	15.24	14.52
1995	16.86	16.29	15.48	9.03	8.84	9.67	14.46	12.53
1996	16.37	16.80	16.02	18.98	18.53	18.89	17.70	14.58
1997	17.39	15.33	14.36	17.35	16.09	17.13	20.42	16.75
1998	17.33	14.39	14.34	14.74	14.26	14.41	13.07	14.15
1999	21.47	20.73	20.45	25.31	23.31	23.83	22.14	18.04
2000	17.70	17.73	18.00	18.90	18.52	18.37	17.96	16.36
Avg	17.71	17.71	17.97	18.90	18.51	18.37	18.00	16.33

COMPOSITE CONSUMPTIVE USE OF IRRIGATION WATER FOR ALL CROPS

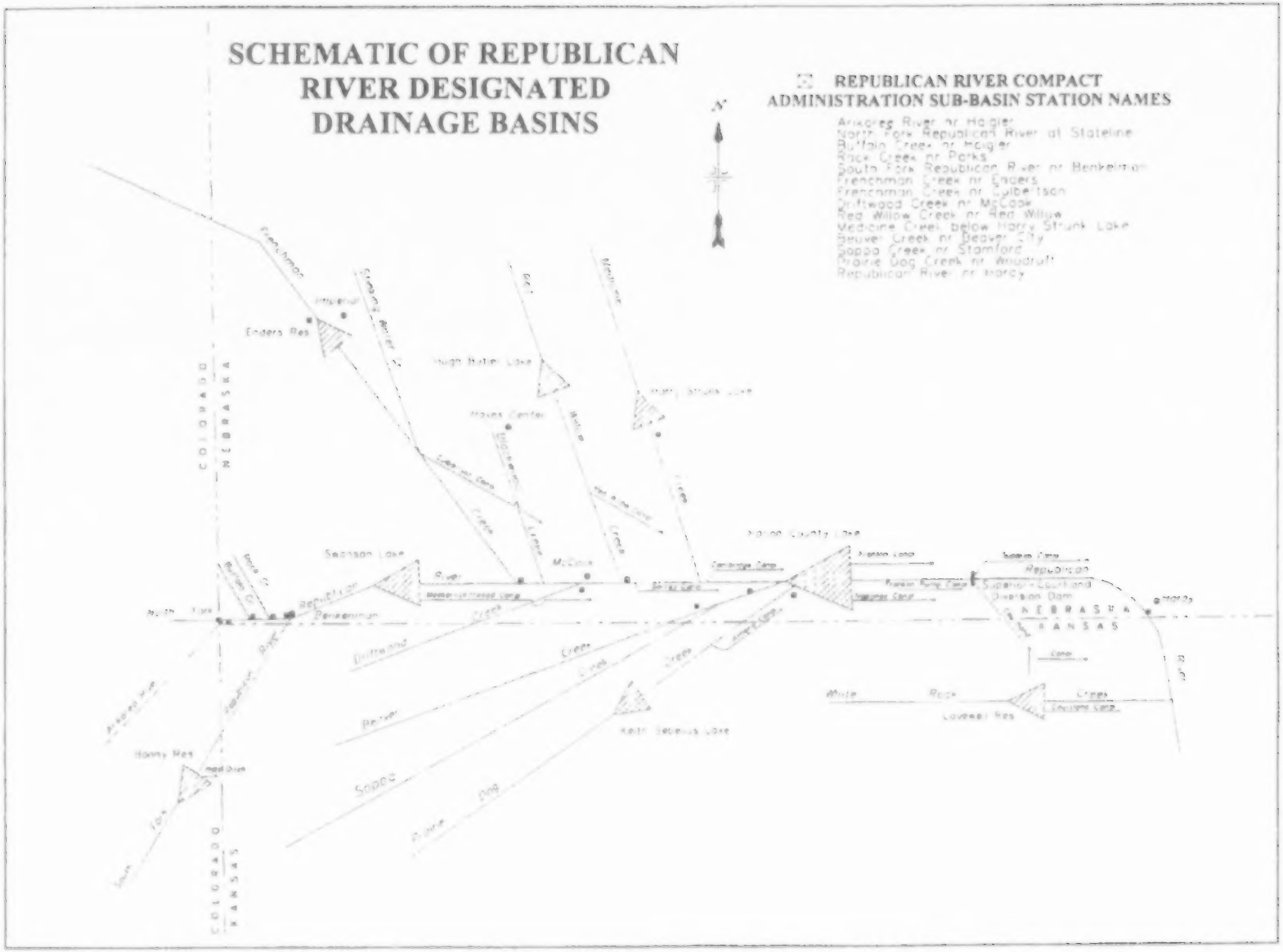
Republican Basin Counties in Kansas

Inches

	KS. Cheyenne	KS. Decatur	KS. Gove	KS. Graham	KS. Jewell	KS. Logan	KS. Norton	KS. Phillips	KS. Rawlins	KS. Rooks	KS. Sheridan	KS. Sherman	KS. Thomas	KS. Trego	KS. Wallace
1940	19.28	21.61	15.94						22.25		16.90	16.21		16.86	
1941	17.24	11.63	13.69			14.10			16.01		13.78	16.01		13.10	
1942	18.82	17.35	15.43			13.70	18.02		18.89		15.34	17.48	20.01	15.19	18.18
1943	19.85	19.09	17.20			17.81	18.63		20.48		17.78	17.34	19.10	18.80	19.06
1944	15.76	12.33	12.61			11.63	15.23		16.02		12.73	16.18	15.26	11.98	14.97
1945	16.77	16.31	15.51			17.24	17.57		16.25		16.14	16.81	18.61	16.82	17.90
1946	20.36	17.27	16.76			18.35	19.12		20.63		17.56	20.78	20.40	17.20	19.53
1947	18.43	17.31	16.92			16.79	16.68		18.62		16.40	17.60	17.28	20.05	17.13
1948	16.46	15.50	13.79			15.20	17.98		16.79		14.36	16.51	19.07	11.92	16.03
1949	15.83	14.11	14.36			12.88	16.84		16.08		13.99	15.03	17.73	14.79	14.47
1950	18.11	18.08	13.46			12.24	17.53	15.20	18.76		13.67	18.49	18.66	12.38	19.47
1951	12.65	11.01	10.53			7.84	12.12	11.65	11.90		9.64	13.04	12.69	9.06	12.65
1952	21.94	20.57	17.99			18.74	19.62	19.38	22.60		18.74	21.03	19.95	19.35	20.85
1953	19.76	15.19	15.88			13.38	16.35	15.66	19.35		14.90	17.96	16.33	13.51	18.34
1954	21.24	18.69	16.00	17.54		18.56	17.42	18.15	20.50		16.74	20.27	17.21	16.07	19.58
1955	21.39	19.05	15.59	17.08		18.96	18.74	18.62	19.65	17.10	16.92	21.00	19.22	14.65	20.32
1956	21.23	18.63	18.35	18.93	24.06	18.71	20.07	18.27	20.04	17.84	17.83	21.87	20.91	16.19	22.86
1957	19.78	18.21	17.33	17.20	23.72	16.61	17.82	16.60	18.63	17.17	16.91	17.37	17.10	16.65	17.29
1958	16.41	13.75	11.51	15.28	13.52	13.55	14.66	13.19	14.12	12.06	12.14	18.29	13.59	10.38	17.36
1959	18.58	16.03	14.28	15.13	16.26	16.06	18.29	17.10	16.78	13.90	14.52	18.41	17.36	12.10	18.00
1960	20.32	17.60	14.96	18.14	13.51	14.67	16.90	14.78	18.86	13.70	14.35	20.98	16.13	12.74	20.39
1961	15.37	15.77	10.12	11.18	16.73	15.12	15.34	15.25	15.01	10.20	11.48	15.31	15.10	5.77	15.48
1962	12.09	10.96	11.44	13.26	17.33	12.05	12.09	11.39	10.87	11.57	13.43	16.04	12.29	11.85	14.03
1963	18.89	17.28	13.60	16.39	17.56	13.79	16.21	16.21	17.79	13.97	13.64	18.64	15.34	14.55	19.16
1964	20.39	15.17	17.39	19.77	15.99	18.26	20.12	18.91	18.42	18.22	17.76	21.62	20.41	17.02	20.95
1965	15.64	10.55	9.29	11.66	15.87	11.16	11.14	11.33	14.61	9.98	9.92	17.39	11.67	8.93	16.16
1966	18.36	13.84	14.76	17.53	19.71	12.72	17.21	15.71	18.66	15.10	14.44	19.36	17.14	14.80	19.72
1967	18.58	14.84	15.09	13.97	16.47	12.15	19.36	12.96	18.91	12.52	14.35	18.19	19.42	12.11	18.41
1968	18.58	12.68	12.34	16.80	17.36	13.56	15.69	15.18	18.35	13.53	13.22	18.91	14.54	11.09	18.31
1969	18.60	16.83	13.70	15.16	13.99	14.36	16.21	14.16	17.38	14.60	14.56	17.96	15.90	13.62	17.25
1970	19.90	17.19	14.96	16.61	18.13	17.59	18.13	19.58	18.26	16.85	16.66	21.05	17.33	15.79	19.78
1971	20.22	16.01	17.05	19.70	19.60	18.59	19.26	18.51	20.80	19.76	18.41	21.66	19.24	18.07	20.28
1972	15.15	13.27	15.13	15.67	15.69	16.07	16.47	14.69	14.51	15.10	14.84	17.04	17.37	14.70	16.19
1973	18.16	17.07	14.98	18.36	14.45	20.12	15.87	16.70	18.03	18.77	16.91	19.23	16.42	15.94	19.87
1974	19.08	17.46	18.78	21.17	22.07	21.84	18.64	20.36	18.16	22.41	19.94	22.43	18.76	21.11	21.80
1975	18.05	12.94	12.91	13.97	12.79	15.81	13.51	13.98	16.51	14.92	13.75	19.20	15.63	13.43	18.87
1976	21.36	19.06	19.87	21.06	20.68	24.23	22.68	22.44	20.81	22.52	22.39	23.19	22.81	19.20	23.20
1977	15.88	12.63	13.61	16.54	14.84	16.13	13.56	14.66	13.50	16.47	14.82	17.46	13.85	13.69	17.12
1978	20.12	17.41	17.70	17.66	18.40	19.65	19.81	15.92	18.43	19.34	19.06	21.19	20.41	16.72	21.57
1979	16.08	10.63	13.33	14.58	21.01	13.78	14.27	13.30	15.74	15.36	14.00	15.22	13.81	14.10	15.69
1980	15.26	19.44	18.11	20.48	24.65	21.31	20.66	20.63	17.09	21.13	20.26	14.23	19.84	18.77	14.32
1981	16.10	16.68	16.62	15.50	16.44	14.52	18.47	13.53	14.13	15.50	16.21	18.21	17.73	16.66	19.34
1982	13.98	14.90	12.95	14.29	13.97	15.41	12.80	15.20	14.25	14.44	14.86	12.84	12.89	14.18	13.26
1983	18.33	17.15	16.27	17.20	17.34	19.05	18.63	19.89	19.48	18.39	18.52	16.77	18.84	17.32	17.25
1984	16.97	15.92	15.52	12.41	18.28	21.86	18.84	21.04	17.58	19.06	18.43	15.71	17.60	15.91	15.69
1985	15.58	14.18	15.38	16.88	14.07	18.28	16.15	17.54	14.62	18.19	16.71	14.54	15.71	16.92	14.53
1986	17.65	13.30	15.59	15.08	15.05	16.88	20.04	15.75	17.59	15.50	16.45	18.25	18.86	13.83	18.06
1987	15.54	14.24	14.12	15.50	16.68	16.35	15.91	15.07	16.62	15.91	15.20	16.21	15.65	14.97	16.20
1988	16.69	13.45	17.57	18.52	22.74	18.70	18.80	15.31	18.34	19.15	18.35	16.30	19.23	17.05	16.83
1989	16.69	14.86	14.46	15.66	17.11	15.84	16.01	15.21	20.47	18.83	15.53	14.84	16.33	15.56	15.23
1990	18.13	17.95	16.20	16.88	17.62	18.92	20.54	16.97	20.72	20.13	17.71	17.31	19.76	16.08	18.11
1991	13.66	13.27	16.38	16.98	19.05	17.57	17.49	17.38	16.14	22.75	17.07	13.13	17.18	18.33	13.62
1992	14.08	13.65	11.85	13.84	10.99	13.07	14.47	13.07	16.93	16.09	13.01	14.25	14.15	12.74	14.81
1991	11.71	8.74	9.74	11.04	6.77	10.06	12.59	7.64	12.47	11.36	10.01	11.24	12.60	9.36	11.58
1994	18.03	13.60	17.12	17.26	17.86	14.21	17.76	13.75	18.25	19.12	16.78	19.26	18.11	18.56	20.30
1995	16.72	19.84	15.98	17.10	15.31	19.68	17.23	18.92	18.56	19.02	17.61	15.20	17.54	15.06	16.25
1996	12.21	9.63	9.83	10.86	14.66	10.39	10.99	8.62	9.68	11.28	10.27	14.92	10.23	10.90	15.45
1997	15.99	17.66	14.01	15.13	15.08	15.60	17.02	16.76	17.38	15.91	14.92	16.29	16.77	12.75	16.78
1998	16.78	15.88	13.97	16.80	22.74	16.52	16.33	15.98	18.49	19.18	15.05	17.40	15.86	14.10	17.84
1999	14.42	11.22	14.26	14.04	17.45	13.10	16.39	12.41	15.08	15.35	13.52	15.80	15.67	14.58	15.17
2000	21.83	22.19	20.03	20.25	20.65	17.73	24.27	17.57	23.99	21.47	19.54	20.87	23.65	20.26	21.09
40-00 Avg	17.41	15.51	14.79	16.83	16.84	15.91	16.92	15.79	17.40	16.43	15.45	17.60	16.97	14.71	17.64

APPENDIX M

SCHEMATIC OF REPUBLICAN RIVER DESIGNATED DRAINAGE BASINS


SCHEMATIC OF REPUBLICAN RIVER DESIGNATED DRAINAGE BASINS
REPUBLICAN RIVER COMPACT ADMINISTRATION SUB-BASIN STATION NAMES
Arikaree River nr Haigler
North Fork Republican River at Stateline
Buffalo Creek nr Haigler
Rock Creek nr Parks
South Fork Republican River nr Benkelman
Frenchman Creek nr Enders
Frenchman Creek nr Wilbertson
Driftwood Creek nr McCook
Red Willow Creek nr Red Willow
Medicine Creek below Harry Strunk Lake
Beaver Creek nr Beaver City
Sappa Creek nr Stamford
Prairie Dog Creek nr Woodruff
Republican River nr Hardy
COLORADO
NEBRASKA
KANSAS
Enders Res
Hugh Butler Lake
Harry Strunk Lake
Hayes Center
Medicine Creek
Beaver Creek
Sappa Creek
Prairie Dog
Republican
Swanson Lake
McCook
Red Willow Creek
Driftwood Creek
Harry Res
Keith Sebelius Lake
Lovewell Res
White Rock Creek
Superior-Courtland Diversion Dam
Hardy

APPENDIX N
PHREATOPHYTE DISTRIBUTION

Appendix N – Phreatophyte Distribution

Colorado – The Colorado Gap Analysis Project (CO-GAP) was initiated in 1991 as a cooperative effort among federal, state, and private natural resource groups in Colorado. The major objectives of the project are to: map actual land cover as closely as possible and make all GAP Project information available to users in a readily accessible format to institutions, agencies, and private land owners. Landsat imagery was acquired or interpreted to establish a baseline map of vegetation and land cover. Attributes were assigned to each polygon describing primary, secondary, and other land cover, crown closure for forested primary types, and the types of wetlands and/or disturbance found in the polygon, if any. Polygon attributes were assigned using image interpretation, existing maps, field reconnaissance, digital reference layers from Federal land management agencies, and literature sources.

Kansas – Landsat TM7 imagery from 2000 was obtained covering most of the RRCA Model area, except for the far south-central and far eastern portions. Tributaries with visible phreatophyte cover were mapped as a subset of the hydrographic drainage network available as a digital line graph from the USGS. Tributaries were then divided according to the relative width of the riparian cover. Within each of these discrete reaches, cross sections from the outside boundaries of the riparian vegetation were then mapped and the average cross section within the reach was calculated. One-half of this average cross section was used as the distance from the hydrographic channel mapped by the USGS to map a polygon to enclose the riparian phreatophyte corridor along the reach. These polygons were merged with the Nebraska polygons denoting woody phreatophytes because some areas mapped as

woody phreatophytes lay well outside of the riparian corridor.

Nebraska – The Nebraska Department of Natural Resources (NDNR), in association with the Nebraska Conservation and Survey Division maintain a collection of digitally rectified aerial photography for landscape analysis. This data has a resolution of 20-ft. and was projected in UTM, Nad83. The NDNR digitized the 1993 Digital Orthophoto Quarter Quadrangle to identify phreatophyte forests from visual examination of the black and white aerial photography at a scale of 1:15,000. Polygons were fit over the photographs in ESRI's Arc View GIS then reprojected into the RRCA Model projection (UTM, Nad27). Approximately 100 sites were visually inspected during field reconnaissance to verify the distribution of woody phreatophytes obtained from the aerial photography. The polygon output provided by Kansas was combined with the aerial photography analysis by Nebraska to include wetland areas in the minor tributaries, with corrections to exclude polygons of irrigated croplands. To accommodate the synoptic biases due to scale, polygon correction was performed at a scale of 1:50,000. Polygons to represent the phreatophyte areas downstream of Red Cloud, Nebraska and the extended groundwater mound area in Kearney and Adams County, Nebraska were derived from aerial photography at a scale of 1:50,000.

Appendix N Phreatophyte Evapotranspiration Rates (example)

Phreatophyte Monthly ET Rates (Inches)

Month	Akron	McCook	Red Cloud
19180100	0.19	0.24	0.07
19180200	0.63	0.72	0.51
19180300	1.69	2.25	1.66
19180400	1.60	2.62	2.00
19180500	7.28	7.31	4.25
19180600	9.47	11.13	9.07
19180700	8.37	7.90	7.05
19180800	6.22	6.74	7.14
19180900	4.67	5.62	5.13
19181000	2.74	2.06	1.86
19181100	0.74	1.00	0.46
19181200	0.04	0.14	0.00
19190100	0.54	0.81	0.98
19190200	0.47	0.00	0.00
19190300	1.40	1.15	1.35
19190400	0.86	1.61	0.88
19190500	5.41	6.41	4.57
19190600	7.81	7.58	5.82
19190700	10.69	9.80	10.33
19190800	10.27	7.88	9.16
19190900	6.94	7.32	2.09
19191000	3.00	2.58	1.54
19191100	0.78	0.31	0.00
19191200	0.46	0.44	0.26
19200100	0.81	0.81	0.78
19200200	0.87	0.85	0.58
19200300	1.28	1.98	2.13
19200400	0.00	0.95	1.23
19200500	4.29	5.64	5.30
19200600	5.40	8.35	8.16
19200700	7.26	10.35	9.16
19200800	8.22	6.84	5.09
19200900	6.78	6.72	4.99
19201000	5.38	2.54	2.45
19201100	1.68	0.78	0.33
19201200	0.82	0.48	0.54
19210100	0.24	0.38	0.60
19210200	1.00	1.15	1.07
19210300	1.36	2.03	2.23
19210400	2.38	4.47	2.86
19210500	7.84	7.21	6.07
19210600	8.56	9.19	8.63
19210700	9.31	9.19	7.50
19210800	8.77	7.15	8.17
19210900	6.62	5.48	3.48
19211000	2.38	1.82	2.18
19211100	1.16	1.07	1.16
19211200	0.65	0.91	0.87
19220100	0.56	0.66	0.65
19220200	0.82	0.81	0.86
19220300	1.67	1.38	0.96
19220400	0.78	2.06	2.41
19220500	6.11	7.01	6.17
19220600	8.88	8.54	9.74
19220700	8.32	8.68	7.68
19220800	9.81	9.19	9.76
19220900	8.15	6.09	5.84
19221000	3.20	2.63	1.82
19221100	0.12	0.30	0.65
19221200	0.98	0.67	0.83
19230100	1.08	0.82	0.98
19230200	0.77	0.78	0.92
19230300	0.91	1.13	0.77
19230400	1.77	1.56	1.89
19230500	3.18	1.76	4.42
19230600	7.13	6.08	4.50
19230700	7.26	8.10	7.56
19230800	8.57	9.29	6.56
19230900	6.89	5.67	4.50
19231000	2.06	1.38	1.56
19231100	1.38	2.15	1.01
19231200	0.10	1.03	0.75

Appendix H Sub-Basin Factors

YEAR	SWANSON	HARLAN	FRENCHMAN	MEDICINE	PHARMEDOC	MEDWILLOW	SJ ARVISONNY	SFBLWBONNY	SAPPA	NORTHFORK	BEAVER	ARIKAREE	BUFFALO	ROCK	DRIFTWOOD
1938	1.00	0.67	1.00	0.40	0.67	1.00	0.25	0.03	0.67	0.47	0.67	0.47	0.30	0.13	0.27
1939	1.00	0.67	1.00	0.42	0.67	1.00	0.25	0.05	0.67	0.49	0.67	0.49	0.33	0.16	0.30
1940	1.00	0.67	1.00	0.43	0.67	1.00	0.26	0.08	0.67	0.52	0.67	0.52	0.35	0.19	0.32
1941	1.00	0.67	1.00	0.45	0.67	1.00	0.26	0.11	0.67	0.55	0.67	0.55	0.38	0.22	0.34
1942	1.00	0.67	1.00	0.47	0.67	1.00	0.26	0.14	0.67	0.58	0.67	0.58	0.41	0.25	0.36
1943	1.00	0.67	1.00	0.49	0.67	1.00	0.26	0.17	0.67	0.61	0.67	0.61	0.44	0.28	0.39
1944	1.00	0.67	1.00	0.51	0.67	1.00	0.26	0.20	0.67	0.63	0.67	0.63	0.47	0.31	0.41
1945	1.00	0.67	1.00	0.53	0.67	1.00	0.26	0.23	0.67	0.66	0.67	0.66	0.50	0.34	0.43
1946	1.00	0.67	1.00	0.55	0.67	1.00	0.26	0.25	0.67	0.68	0.67	0.68	0.53	0.36	0.46
1947	1.00	0.67	1.00	0.57	0.67	1.00	0.26	0.28	0.67	0.72	0.67	0.72	0.56	0.39	0.48
1948	1.00	0.67	1.00	0.59	0.67	1.00	0.26	0.31	0.67	0.74	0.67	0.74	0.58	0.42	0.50
1949	1.00	0.67	1.00	0.61	0.67	1.00	0.26	0.34	0.67	0.77	0.67	0.77	0.61	0.45	0.53
1950	1.00	0.67	1.00	0.63	0.67	1.00	0.26	0.37	0.67	0.80	0.67	0.80	0.64	0.48	0.55
1951	1.00	0.67	1.00	0.65	0.67	1.00	0.31	0.38	0.67	0.83	0.67	0.83	0.67	0.51	0.57
1952	1.00	0.67	1.00	0.67	0.67	1.00	0.33	0.42	0.67	0.86	0.67	0.86	0.70	0.54	0.59
1953	1.00	0.67	1.00	0.69	0.67	1.00	0.35	0.45	0.67	0.86	0.67	0.88	0.73	0.57	0.62
1954	1.00	0.67	1.00	0.71	0.67	1.00	0.37	0.48	0.67	0.91	0.67	0.91	0.76	0.60	0.64
1955	1.00	0.67	1.00	0.73	0.67	1.00	0.40	0.51	0.67	0.94	0.67	0.94	0.78	0.63	0.66
1956	1.00	0.67	1.00	0.75	0.67	1.00	0.42	0.53	0.67	0.97	0.67	0.97	0.81	0.66	0.69
1957	1.00	0.67	1.00	0.77	0.67	1.00	0.44	0.56	0.67	1.00	0.67	1.00	0.84	0.68	0.71
1958	1.00	0.67	1.00	0.79	0.67	1.00	0.47	0.59	0.67	1.02	0.67	1.02	0.87	0.72	0.73
1959	1.00	0.67	1.00	0.81	0.67	1.00	0.49	0.62	0.67	1.05	0.67	1.05	0.90	0.75	0.76
1960	1.00	0.67	1.00	0.83	0.67	1.00	0.51	0.65	0.67	1.05	0.67	1.05	0.92	0.78	0.78
1961	1.00	0.67	1.00	0.85	0.67	1.00	0.53	0.67	0.67	1.05	0.67	1.05	0.94	0.81	0.80
1962	1.00	0.67	1.00	0.87	0.67	1.00	0.56	0.67	0.67	1.07	0.67	1.07	0.95	0.83	0.82
1963	1.00	0.67	1.00	0.89	0.67	1.00	0.58	0.67	0.67	1.08	0.67	1.08	0.97	0.86	0.85
1964	1.00	0.67	1.00	0.91	0.67	1.00	0.60	0.67	0.67	1.09	0.67	1.09	0.99	0.89	0.87
1965	1.00	0.67	1.00	0.91	0.67	1.00	0.62	0.67	0.67	1.09	0.67	1.09	1.01	0.92	0.89
1966	1.00	0.67	1.00	0.91	0.67	1.00	0.65	0.67	0.67	1.10	0.67	1.10	1.01	0.93	0.90
1967	1.00	0.67	1.00	0.92	0.67	1.00	0.67	0.67	0.67	1.11	0.67	1.11	1.02	0.93	0.91
1968	1.00	0.67	1.00	0.92	0.67	1.00	0.68	0.67	0.67	1.11	0.67	1.11	1.02	0.93	0.92
1969	1.00	0.67	1.00	0.92	0.67	1.00	0.70	0.67	0.67	1.12	0.67	1.12	1.03	0.93	0.93
1970	1.00	0.67	1.00	0.92	0.67	1.00	0.71	0.67	0.67	1.09	0.67	1.09	1.01	0.94	0.92
1971	1.00	0.67	1.00	0.93	0.67	1.00	0.72	0.67	0.67	1.08	0.67	1.08	1.01	0.94	0.92
1972	1.00	0.67	1.00	0.93	0.67	1.00	0.73	0.67	0.67	1.10	0.67	1.10	1.01	0.94	0.92
1973	1.00	0.67	1.00	0.93	0.67	1.00	0.75	0.67	0.67	1.09	0.67	1.09	1.01	0.94	0.93
1974	1.00	0.67	1.00	0.94	0.67	1.00	0.76	0.67	0.67	1.09	0.67	1.09	1.01	0.95	0.93
1975	1.00	0.67	1.00	0.94	0.67	1.00	0.77	0.67	0.67	1.08	0.67	1.08	1.02	0.95	0.93
1976	1.00	0.67	1.00	0.94	0.67	1.00	0.78	0.67	0.67	1.08	0.67	1.08	1.01	0.95	0.94
1977	1.00	0.67	1.00	0.95	0.67	1.00	0.80	0.67	0.67	1.07	0.67	1.07	1.01	0.96	0.95
1978	1.00	0.67	1.00	0.95	0.67	1.00	0.81	0.67	0.67	1.07	0.67	1.07	1.01	0.96	0.95
1979	1.00	0.67	1.00	0.95	0.67	1.00	0.82	0.67	0.67	1.06	0.67	1.06	1.01	0.96	0.95
1980	1.00	0.67	1.00	0.95	0.67	1.00	0.84	0.67	0.67	1.06	0.67	1.06	1.01	0.96	0.96
1981	1.00	0.67	1.00	0.95	0.67	1.00	0.85	0.67	0.67	1.05	0.67	1.05	1.01	0.97	0.96
1982	1.00	0.67	1.00	0.96	0.67	1.00	0.86	0.67	0.67	1.05	0.67	1.05	1.01	0.97	0.96
1983	1.00	0.67	1.00	0.97	0.67	1.00	0.87	0.67	0.67	1.05	0.67	1.05	1.01	0.97	0.97
1984	1.00	0.67	1.00	0.97	0.67	1.00	0.89	0.67	0.67	1.04	0.67	1.04	1.01	0.97	0.97
1985	1.00	0.67	1.00	0.97	0.67	1.00	0.90	0.67	0.67	1.04	0.67	1.04	1.01	0.98	0.97
1986	1.00	0.67	1.00	0.97	0.67	1.00	0.91	0.67	0.67	1.03	0.67	1.03	1.01	0.98	0.98
1987	1.00	0.67	1.00	0.98	0.67	1.00	0.92	0.67	0.67	1.03	0.67	1.03	1.00	0.98	0.98
1988	1.00	0.67	1.00	0.98	0.67	1.00	0.94	0.67	0.67	1.02	0.67	1.02	1.00	0.98	0.98
1989	1.00	0.67	1.00	0.98	0.67	1.00	0.95	0.67	0.67	1.02	0.67	1.02	1.00	0.99	0.99
1990	1.00	0.67	1.00	0.98	0.67	1.00	0.96	0.67	0.67	1.01	0.67	1.01	1.00	0.99	0.99
1991	1.00	0.67	1.00	0.99	0.67	1.00	0.97	0.67	0.67	1.01	0.67	1.01	1.00	0.99	0.99
1992	1.00	0.67	1.00	0.99	0.67	1.00	0.99	0.67	0.67	1.00	0.67	1.00	1.00	0.99	0.99
1993	1.00	0.67	1.00	1.00	0.67	1.00	1.00	0.67	0.67	1.00	0.67	1.00	1.00	1.00	1.00
1994	1.00	0.67	1.00	1.00	0.67	1.00	1.00	0.67	0.67	1.00	0.67	1.00	1.00	1.00	1.00
1995	1.00	0.67	1.00	1.00	0.67	1.00	1.00	0.67	0.67	1.00	0.67	1.00	1.00	1.00	1.00
1996	1.00	0.67	1.00	1.00	0.67	1.00	1.00	0.67	0.67	1.00	0.67	1.00	1.00	1.00	1.00
1997	1.00	0.67	1.00	1.00	0.67	1.00	1.00	0.67	0.67	1.00	0.67	1.00	1.00	1.00	1.00
1998	1.00	0.67	1.00	1.00	0.67	1.00	1.00	0.67	0.67	1.00	0.67	1.00	1.00	1.00	1.00
1999	1.00	0.67	1.00	1.00	0.67	1.00	1.00	0.67	0.67	1.00	0.67	1.00	1.00	1.00	1.00
2000	1.00	0.67	1.00	1.00	0.67	1.00	1.00	0.67	0.67	1.00	0.67	1.00	1.00	1.00	1.00

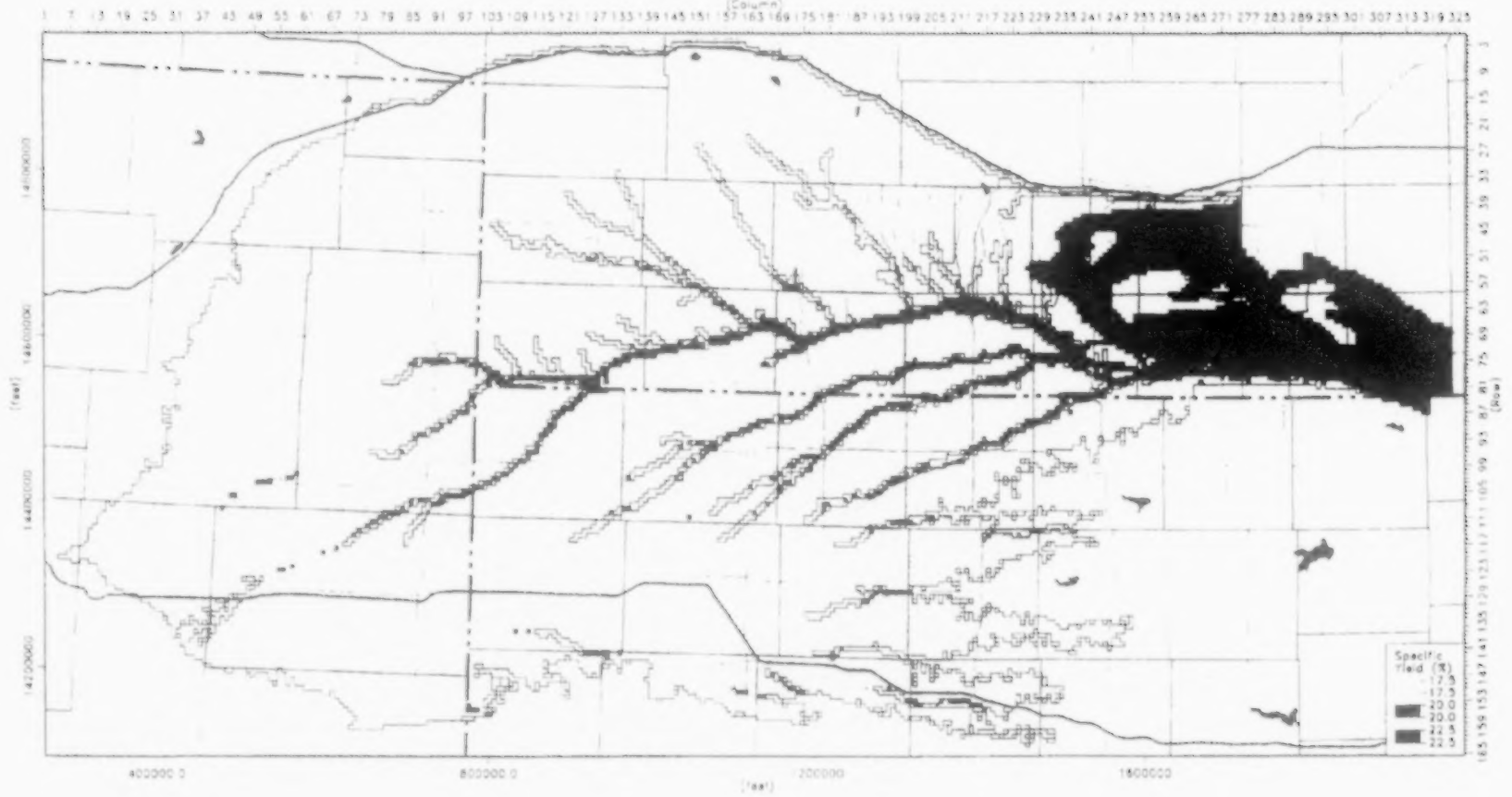
N4

APPENDIX O

DISTRIBUTION OF SPECIFIC YIELDS

Distribution of Specific Yield

Republican River Settlement Model Version 12p

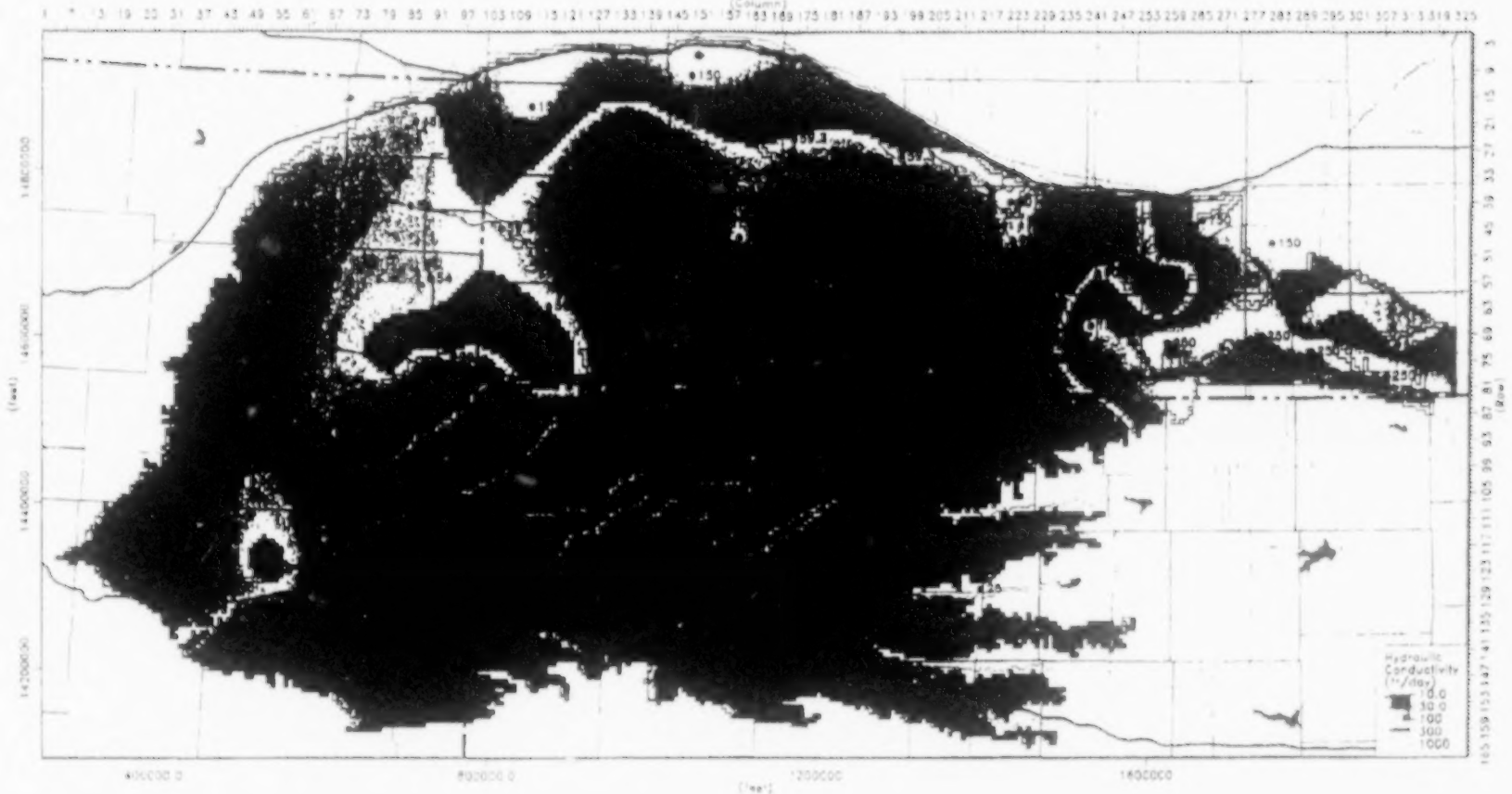


APPENDIX P

DISTRIBUTION OF HYDRAULIC CONDUCTIVITIES

Distribution of Hydraulic Conductivity

Republican River Settlement Model Version 12p

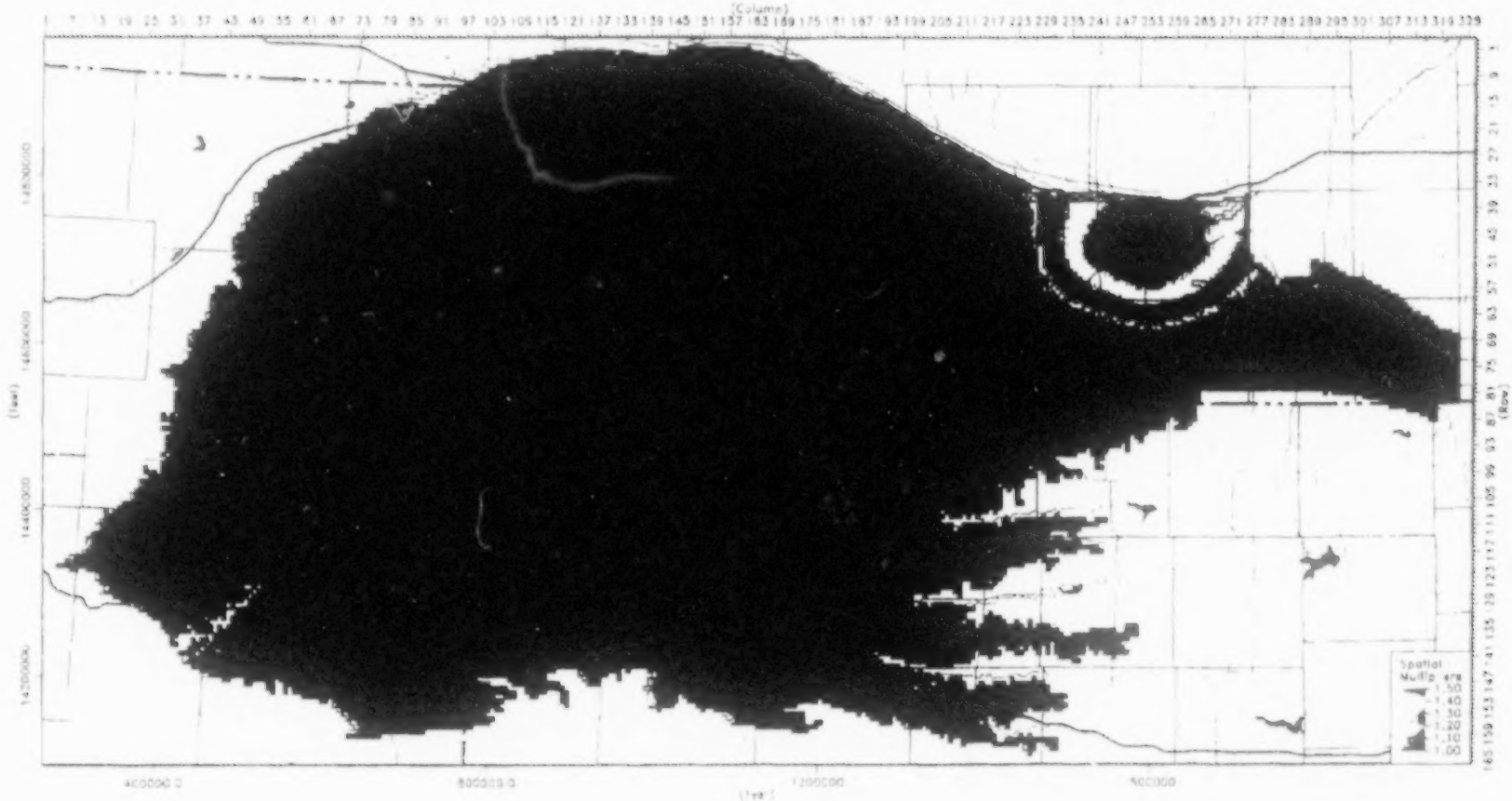


APPENDIX Q
SPATIAL MULTIPLIERS

Q1

Spatial Multipliers

Republican River Settlement Model Version 12p

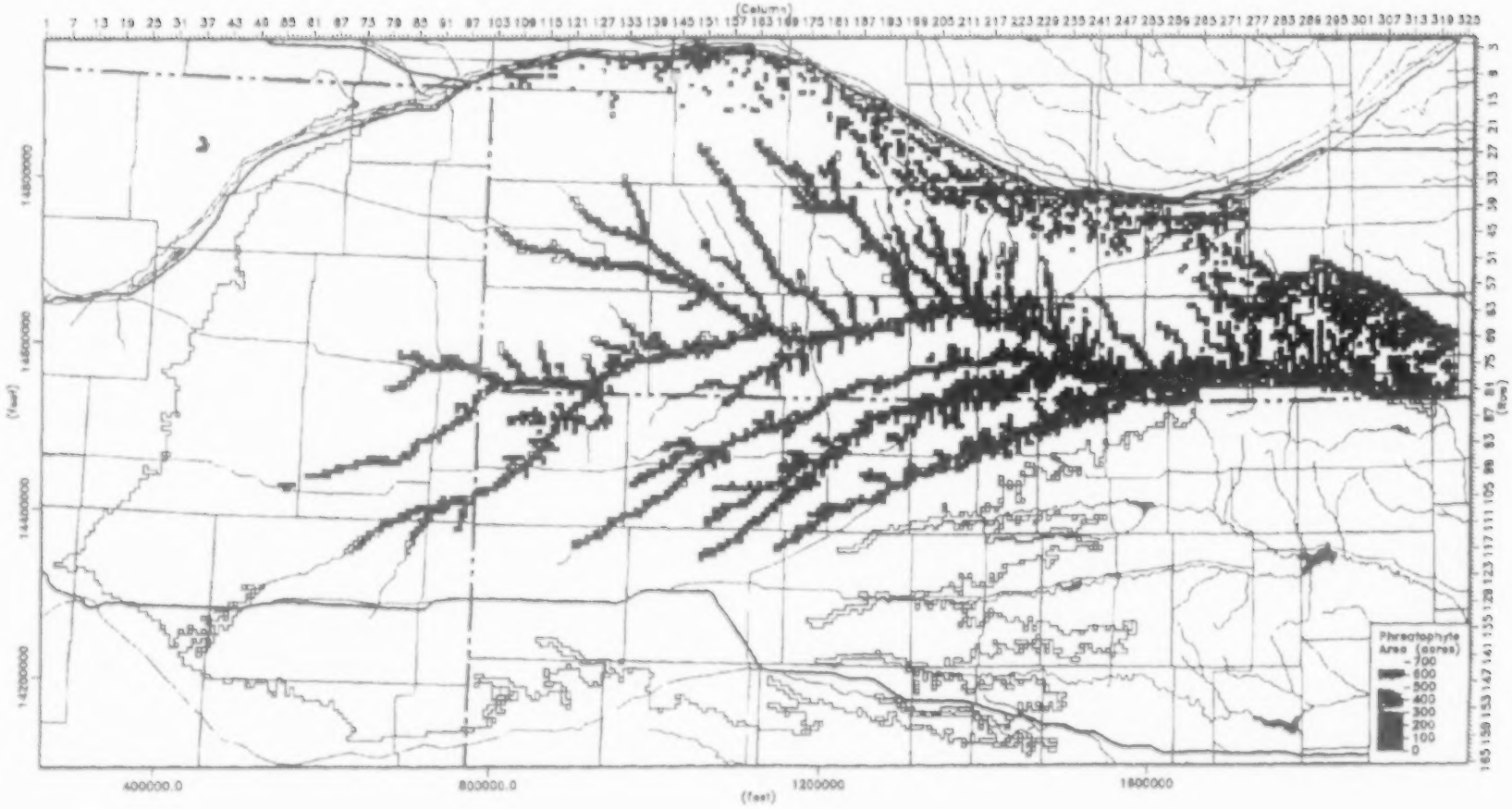


APPENDIX R

PHREATOPHYTE AREA AND LOCATION OF PHREATOPHYTE SUB-BASINS

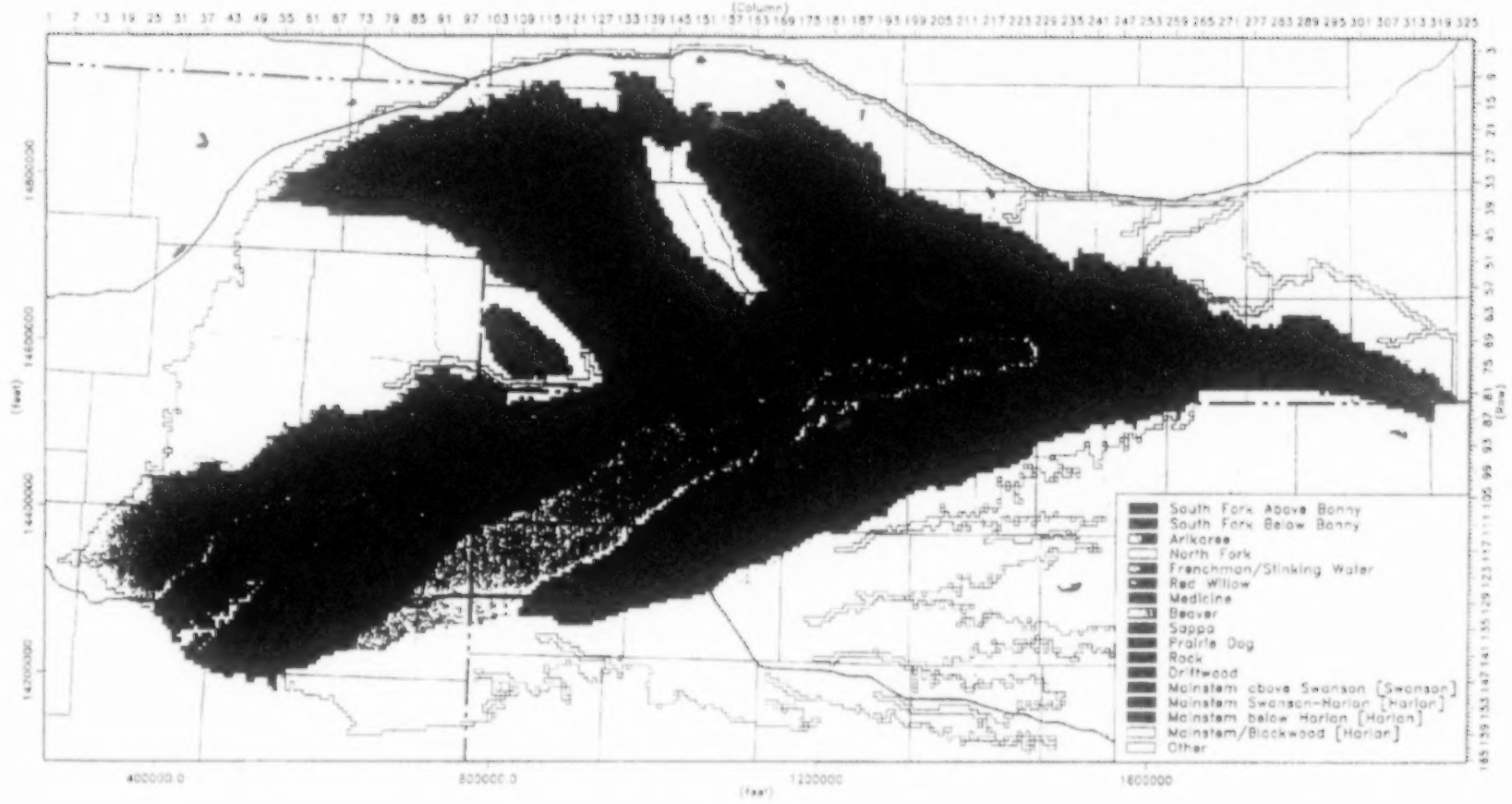
Phreatophyte Area

Republican River Settlement Model Version 12p



Location of Phreatophyte Sub-Basins

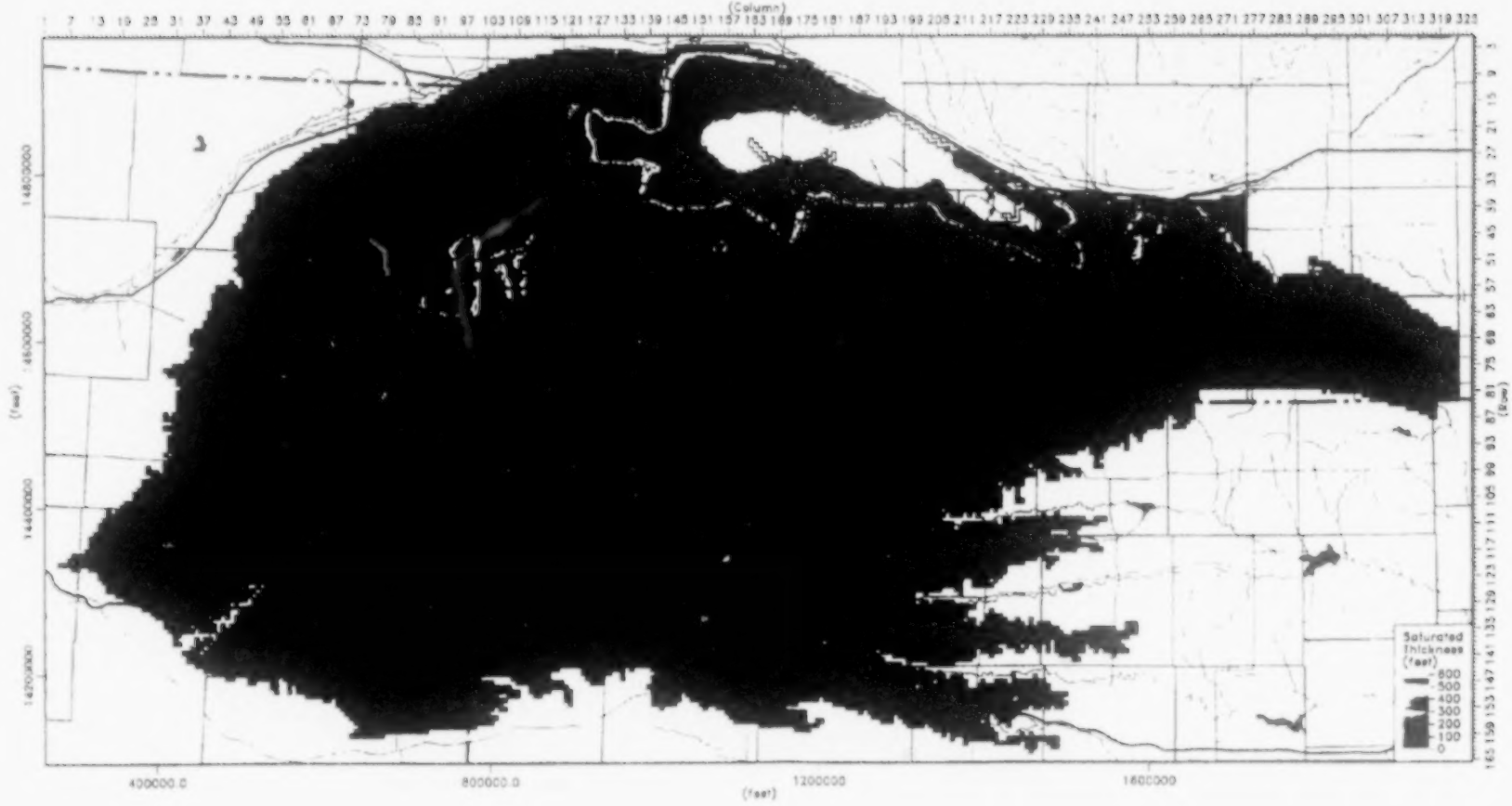
Republican River Settlement Model Version 12p



APPENDIX S
SATURATED THICKNESS

Saturated Thickness

Republican River Settlement Model Version 12p

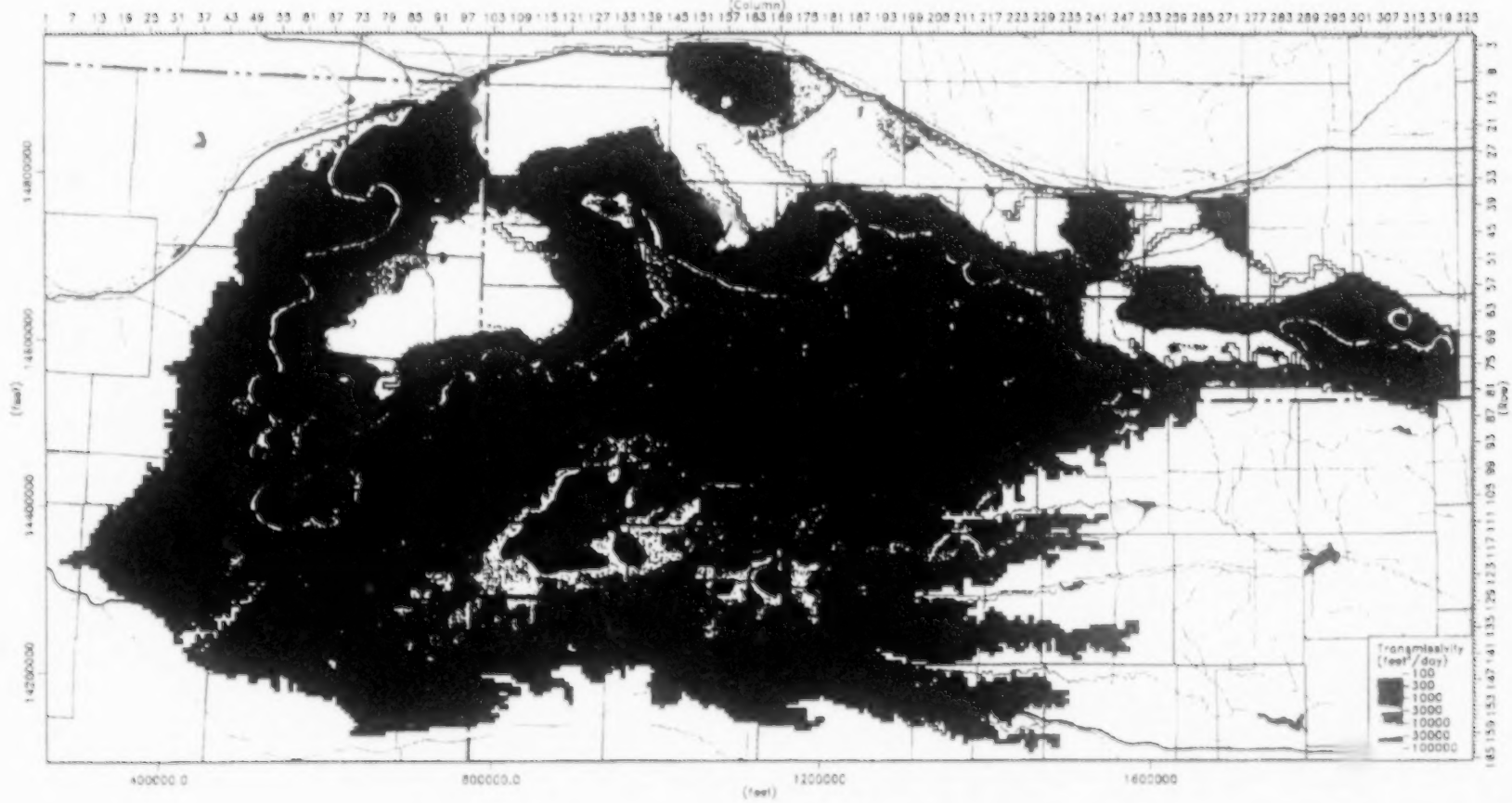


APPENDIX T
TRANSMISSIVITY

T1

Transmissivity

Republican River Settlement Model Version 12p



APPENDIX U
RRCA MODEL IMPACTS

Appendix U RRCA Model Impacts

Version 12p: Impact of Colorado Pumping (acre-feet)

Year	Arikaree	Beaver	Buffalo	Driftwood	Frenchman	North Fork	Above Swanson	Swanson-Harlan	Harlan-Guide Rock	Guide Rock-Hardy	Medicine	Prairie Dog	Red Willow	Rock	Sappa	South Fork	Hugh Butler	Bonny	Keith Sebelius	Enders	Harlan	Harry Strunk	Swanson	Mainstem Total	Total
1981	1049	0	33	0	255	7485	-540	0	0	0	0	0	0	0	0	9654	0	758	0	0	0	0	0	-540	18705
1982	2335	0	40	0	305	7822	-883	0	0	0	0	0	0	0	0	8566	0	760	0	0	0	0	0	-883	18954
1983	1678	0	46	0	366	7908	-1775	0	0	0	0	0	0	0	0	8193	0	780	0	0	0	0	0	-1775	17208
1984	1109	0	53	0	421	8342	-1391	0	0	0	0	0	0	0	0	7822	0	836	0	0	0	0	0	-1391	17205
1985	516	0	61	0	471	8827	-1455	0	0	0	0	0	0	0	0	9579	0	841	0	0	0	0	0	-1455	18656
1986	455	0	69	0	532	8757	-1572	0	0	0	0	0	0	0	0	7544	0	880	0	0	0	0	0	-1572	16661
1987	511	0	78	0	604	9258	-1699	0	0	0	0	0	0	11	0	9783	0	900	0	0	0	0	0	-1699	19451
1988	956	0	89	0	676	9684	-1978	0	0	0	0	0	0	12	0	7770	0	980	0	0	0	0	0	-1978	18157
1989	245	0	98	0	724	9786	-1957	0	0	0	0	0	0	13	0	8552	0	968	0	0	0	0	0	-1957	18417
1990	589	0	109	0	713	10428	-2114	0	0	0	0	0	0	15	0	9811	0	985	0	0	0	0	0	-2114	20543
1991	1482	0	121	0	738	10837	-1181	0	0	0	0	0	0	17	0	10622	0	975	0	0	0	0	0	-1182	23598
1992	2233	0	134	0	745	11199	-1052	0	0	0	0	0	0	19	0	10355	0	994	0	0	0	0	0	-1053	24633
1993	2018	0	148	0	1000	11400	-1067	0	0	0	0	0	0	21	0	9497	0	1005	0	0	0	0	0	-1067	24025
1994	1149	0	157	0	901	11807	-2716	0	0	0	0	0	0	23	0	8999	0	1044	0	0	0	0	0	-2717	21171
1995	1870	0	171	0	814	12011	-2056	0	0	0	0	0	0	26	0	12038	0	1053	0	0	0	0	0	-2058	25935
1996	1774	0	184	0	946	12257	-847	-20	0	0	0	0	0	29	0	11006	0	1054	0	0	0	0	0	-867	26391
1997	1587	0	197	0	981	12307	-2563	0	0	0	0	0	0	32	0	9123	0	1078	0	0	0	0	0	-2566	22847
1998	1239	0	207	0	717	12521	-3330	0	0	0	0	0	0	35	0	11280	0	1121	0	0	0	0	0	-3333	23799
1999	981	0	220	0	1010	13004	-781	0	0	0	0	0	0	38	0	12429	0	1116	0	0	0	0	14	-765	28050
2000	1918	0	234	0	599	13173	-4253	0	0	0	0	0	0	42	0	9280	0	1170	0	0	0	0	11	-4252	22178
Average 1981-2000	1289	0	122	0	676	10419	-1759	0	0	0	0	0	0	19	0	9595	0	962	0	0	0	0	0	-1781	21330

Version 12p: Impact of Kansas Pumping (acre-feet)

Year	Arikaree	Beaver	Buffalo	Driftwood	Frenchman	North Fork	Above Swanson	Swanson-Harlan	Harlan-Guide Rock	Guide Rock-Hardy	Medicine	Prairie Dog	Red Willow	Rock	Sappa	South Fork	Hugh Butler	Bonny	Keith Sebelius	Enders	Harlan	Harry Strunk	Swanson	Mainstem Total	Total
1981	216	5205	0	0	0	0	298	214	0	230	0	4068	0	0	-596	11006	0	0	359	0	26	0	0	741	21036
1982	192	5893	0	0	0	0	225	-25	0	165	0	4542	0	0	2068	5907	0	0	486	0	24	0	0	365	19488
1983	96	5812	0	0	0	0	277	-132	0	187	0	4086	0	0	2089	4280	0	0	453	0	21	0	0	332	17176
1984	151	5974	0	0	0	0	191	-320	0	281	0	4055	0	0	2319	7733	0	0	754	0	20	0	0	152	21166
1985	153	5960	0	0	0	11	163	203	0	208	0	3525	0	0	2719	6860	0	0	654	0	19	0	0	573	20277
1986	126	4994	0	0	0	0	198	-201	0	238	0	2195	0	0	905	6038	0	0	818	0	18	0	0	235	15141
1987	170	5189	0	0	0	13	158	76	0	213	0	4496	0	0	244	8101	0	0	561	0	17	0	0	458	19221
1988	154	4567	0	0	0	13	261	-315	0	271	0	2496	0	0	-112	7218	0	0	812	0	18	0	0	217	15187
1989	156	2321	0	0	0	15	185	190	0	213	0	751	0	0	-803	6883	0	0	882	0	17	0	0	589	10414
1990	211	1150	0	0	0	14	-27	123	0	233	0	780	0	0	-758	9855	0	0	841	0	18	0	0	330	12046
1991	276	1223	0	0	0	21	163	20	0	252	0	2180	0	0	-1024	10874	0	0	858	0	19	0	0	436	14469
1992	178	2804	0	0	0	12	426	-50	0	50	0	4455	0	0	-1726	8803	0	0	425	0	17	0	0	428	13302
1993	223	7814	0	0	0	0	236	124	-14	18	0	14168	0	0	2796	5378	0	0	404	0	66	0	0	364	34024
1994	101	7870	0	0	0	0	236	-221	0	188	0	8357	0	0	3782	3327	0	0	475	0	114	0	0	213	21949
1995	202	8882	0	0	0	12	19	-369	0	218	0	3689	0	0	2178	8931	0	0	485	0	83	0	0	-130	22338
1996	211	7005	0	0	0	16	326	328	0	218	0	5819	0	0	3011	7548	0	0	334	0	65	0	0	875	24988
1997	141	6815	0	0	0	14	232	-395	0	178	0	4121	0	0	2478	5911	0	0	427	0	54	0	0	19	19984
1998	187	5618	0	0	0	12	39	-386	0	188	0	2543	0	0	837	7752	0	0	404	0	48	0	0	-178	17212
1999	239	5686	0	0	0	15	352	-32	0	201	0	2479	0	0	-198	8864	0	0	356	0	45	0	0	524	18019
2000	128	4560	0	0	0	15	159	-224	0	257	0	1392	0	0	-670	6320	0	0	407	0	42	0	0	198	12398
Average 1981-2000	175	5146	0	0	0	12	208	-70	0	199	0	3915	0	0	977	7379	0	0	509	0	37	0	0	337	18492

Version 12p: Impact of Nebraska Pumping (acre-feet)

Year	Arikaree	Beaver	Buffalo	Driftwood	Frenchman	North Fork	Above Swanson	Swanson-Harlan	Harlan-Guide Rock	Guide Rock-Hardy	Medicine	Prairie Dog	Red Willow	Rock	Sappa	South Fork	Hugh Butler	Bonny	Keith Sebelius	Enders	Harlan	Harry Strunk	Swanson	Mainstem Total	Total
1981	261	5535	1400	835	50240	271	9755	40493	12594	1492	8788	0	4047	1101	1187	1004	840	0	0	1895	623	188	143	84334	142490
1982	211	5795	1476	830	51039	287	8711	31087	12458	1433	8595	0	3414	1282	2904	807	882	0	0	1802	672	207	136	53688	133825
1983	118	5301	1498	922	51384	356	7137	21529	13871	1541	8768	0	3131	1364	2866	612	926	0	0	1895	681	226	137	44077	124237
1984	181	5281	1550	1039	54388	390	8567	32874	14519	1380	9688	0	3700	1426	2909	673	994	0	0	2037	774	245	150	58340	143724
1985	191	5369	1647	1052	56320	435	10049	36237	14578	1552	10213	0	4168	1504	3263	727	1041	0	0	2200	713	286	157	62414	151681
1986	178	4546	1729	1073	57393	453	9138	28874	14815	1368	10678	0	4039	1590	2129	722	1109	0	0	2342	790	288	155	54195	143406
1987	190	4736	1799	1103	58503	516	9262	35060	15649	1398	11095	0	4227	1705	1461	730	1123	0	0	2440	715	308	154	61370	152178
1988	170	4097	1874	1098	59787	568	9340	30341	18179	1572	11387	0	4174	1833	1269	728	1171	0	0	2547	821	325	160	59432	151420
1989	164	2155	1940	1101	60387	603	9010	28409	17745	1691	11889	0	4153	1915	887	422	1263	0	0	2661	896	342	160	56855	147573
1990	204	1119	2056	1122	63991	692	10898	32804	18139	1803	12775	0	4550	2037	815	794	1336	0	0	2796	909	364	173	63445	158975
1991	298	1446	2221	1150	67075	893	12258	38384	20759	1985	13916	0	5185	2224	578	976	1421	0	0	2933	995	385	188	73388	175048
1992	210	3120	2297	1153	64303	689	10270	49739	18849	1723	13628	0	5476	2373	710	933	1307	0	0	3040	844	404	147	80581	181215
1993	192	7110	2286	1078	63516	693	8532	45586	16874	1404	12098	0	5083	2501	4354	806	1114	0	0	3081	642	409	131	72396	177488
1994	117	8727	2298	1044	67838	792	9125	28337	18783	1399	12198	0	4383	2563	4897	803	1349	0	0	3168	888	417	157	57824	167037
1995	233	8402	2413	1117	70355	848	10632	41753	22113	1905	13895	0	5471	2642	3552	889	1449	0	0	3300	957	436	155	78403	190318
1996	239	6270	2503	1148	70624	860	11074	52870	20709	1878	13887	0	5934	2775	4117	934	1383	0	0	3388	770	452	143	86330	201533
1997	164	5964	2588	1150	72910	970	10951	34408	22506	1830	13892	0	5313	2839	3495	853	1480	0	0	3464	983	464	162	69695	186346
1998	206	4978	2690	1196	73764	1045	10150	35058	21914	1726	14510	0	5338	2894	2419	806	1549	0	0	3606	949	483	180	68649	185481
1999	313	4870	2799	1171	75119	1030	12815	49574	21936	1793	13913	0	6348	3023	1149	1048	1345	0	0	3711	882	494	179	86117	203490
2000	196	3568	2912	1153	74876	1156	10260	30832	25316	1928	14585	0	5179	3125	792	982	1601	0	0	3848	989	505	220	88335	184022
Average 1981-2000	202	4720	2098	1077	63186	667	9947	38203	18114	1630	11999	0	4666	2136	2257	792	1233	0	0	2797	822	360	158	65893	165073

Version 12p: Impact of Nebraska Imports (acre-feet)

Year	Arikaree	Beaver	Buffalo	Driftwood	Frenchman	North Fork	Above Swanson	Swanson-Harlan	Harlan-Guide Rock	Guide Rock-Hardy	Medicine	Prairie Dog	Red Willow	Rock	Sappa	South Fork	Hugh Butler	Bonny	Keith Sebelius	Enders	Harlan	Harry Strunk	Swanson	Mainstem Total	Total
1981	0	0	0	0	0	0	0	8539	49	0	6637	0	11	0	0	0	0	0	0	0	0	0	0	8587	15236
1982	0	0	0	0	0	0	0	6969	56	0	6719	0	13	0	0	0	0	0	0	0	0	0	0	7045	13783
1983	0	0	0	0	0	0	0	6355	53	0	6705	0	13	0	0	0	0	0	0	0	0	0	0	6417	13140
1984	0	0	0	0	0	0	0	8532	70	0	7122	0	15	0	0	0	0	0	0	0	0	0	0	8600	13742
1985	0	0	0	0	0	0	0	9461	80	0	7222	0	16	0	0	0	0	0	0	0	0	0	0	9540	16787
1986	0	0	0	0	0	0	0	5852	68	0	7195	0	15	0	0	0	0	0	0	0	0	0	0	5939	13154
1987	0	0	0	0	0	0	0	9202	100	0	7438	0	18	0	0	0	0	0	0	0	0	0	0	9299	16759
1988	0	0	0	0	0	0	0	8077	107	0	7604	0	20	0	0	0	0	0	0	0	0	0	0	8181	13809
1989	0	0	0	0	0	0	0	6178	114	0	7538	0	18	0	0	0	0	0	0	0	0	0	0	6290	13849
1990	0	0	0	0	0	0	0	7020	115	0	7662	0	19	0	0	0	0	0	0	0	0	0	0	7133	14815
1991	0	0	0	0	0	0	0	4515	113	0	8038	0	20	0	0	0	0	0	0	0	0	0	0	4625	12688
1992	0	0	0	0	0	0	0	6175	100	0	8371	0	24	0	0	0	0	0	0	0	0	0	0	6272	14872
1993	0	0	0	0	0	0	0	15487	191	0	8878	0	40	0	14	0	0	0	0	0	0	0	0	15673	24811
1994	0	0	0	0	0	0	0	7251	188	0	8487	0	30	0	17	0	0	0	0	0	0	0	0	7436	15654
1995	0	0	0	0	0	0	0	8908	189	0	8770	0	35	0	0	0	0	0	0	0	0	0	0	9094	17916
1996	0	0	0	0	0	0	0	14968	219	0	9153	0	39	0	15	0	0	0	0	0	0	0	0	15181	24395
1997	0	0	0	0	0	0	0	7171	204	0	9020	0	39	0	0	0	0	0	0	0	0	0	0	7372	16447
1998	0	0	0	0	0	0	0	8578	174	0	8891	0	34	0	0	0	0	0	0	0	0	0	0	8750	17594
1999	0	0	0	0	0	0	0	8764	155	0	9482	0	33	0	0	0	0	0	0	0	0	0	0	8925	18450
2000	0	0	0	0	0	0	0	9413	158	0	9058	0	31	0	0	0	0	0	0	0	0	0	0	9564	18664
Average 1981-2000	0	0	0	0	0	0	0	8172	127	0	7996	0	24	0	0	0	0	0	0	0	0	0	0	8296	16328